

SUPPLEMENTARY READING MATERIALS IN CHEMISTRY  
IN THE LIGHT OF  
PROFESSIONAL/VOCATIONAL COURSES

DAIRYING

Edited by  
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## P R E F A C E

The Government of India has accepted Vocational Education as a viable link between education and productivity. A target has been set to have 50% of students in the vocational stream although, at present, only 2.5% of the student populace take up vocational courses. There are only 11 States and 5 Union Territories catering to vocational courses. Therefore the goal of inducting 50% students to vocational studies is a gigantic task.

The states which have taken up this programme with the existing resources need textbooks, supplementary reading materials and practical manuals, among other support materials for successful implementation of these courses.

The teacher is another important factor who should be trained for and turned to the vocational courses. Provision has to be made for appropriate teacher education for vocational courses. Meanwhile, as a short term measure a method has to be devised to draw people from industries and other institutions who could use their specialization for teaching these vocations and there should be proper mix of full time and part time teachers.

In view of the importance of the programme and necessity for appropriate and adequate instructional materials, NCERT is making all efforts to provide academic support to different states.

It was felt that chemistry-based vocations are many and a good background of chemistry would be helpful for students belonging to the vocational stream. So a project to develop some supplementary reading materials in chemistry which would be useful in case of a number of vocational courses was taken up.

We strongly felt that along with their training in vocations, the students would benefit from relevant background knowledge from academic disciplines but for which the training in vocations would not be much meaningful.

Keeping in view the essential academic requirements supplementary reading materials were prepared in support of four vocational areas, namely (i) Dairying (ii) Crop Production, (iii) Laboratory Techniques and (iv) Photography.

The book entitled 'Guidelines for the Development of Instructional Materials for Vocational Courses' published by Department of Vocationalization Education, NCERT, was a useful guide for the preparation of these materials.

Materials were prepared during a workshop held in the Department of Education in Science and Mathematics during January 28 to February 2, 1985. Participants worked in groups according to the area of their specialization. Their names as group members and authors are mentioned elsewhere and their contributions are acknowledged.

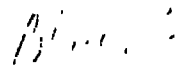
This booklet on dairying attempts to deal with essential chemistry chapters of carbohydrates, lipids, proteins, enzymes, vitamins hormones, fermentation, food colour and dyes, preservatives adulterants and neutralizers, water, solution, acids and bases, indicators, detergents, chemical sanitizers, analysis of water, chemistry of solvents and preparation of reagents. The standards wherever necessary have been given.

We hope this booklet would be useful to those who choose vocations related to Dairying.

I am grateful to participants for their interest and contribution. I am specially thankful to Prof. A.K. Mishra, Head, Department of Vocationalization of Education who took keen

interest in motivating my colleagues in this Department. His introductory remarks in the beginning of the workshop provided important guideliness for the participants. I am also grateful to Dr. A.K. Sachoti, Reader, Department of Vocationalization of Education who contributed to the development of the material. I thank my colleagues Dr. B.D. Atreya, Dr. B. Prakash, Dr. K. Mittal, and Dr.(Mrs.) S.B. Malik for their interest in the project. I appreciate the efforts made by Dr. (Mrs.) S.B. Malik for conducting the workshop, technical editing and bringing out this manual.

Comments for improvement of the manual are welcome.

  
( B. GANGULY )

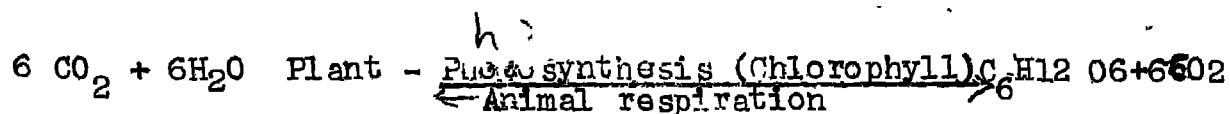


## Carbohydrates

### Introduction:

This class of compounds are among the most common constituents of plants and animals. In animals they provide a source of energy while in plants they form the greater part of the cell tissue on which the plants rely for their support. They include glucose, sucrose, lactose, starch, cellulose, etc. The name originates from the fact that many sugars have the general formula -  $C_n(H_2O)_n$  i.e., carbon hydrate hence the name carbohydrates. Thus glucose and lactose can be written as  $C_6(H_2O)_6$  and  $C_{12}(H_2O)_{11}$  respectively.

They are produced in the nature from carbon dioxide and water by the action of sun light in the presence of chlorophyll ( the green pigment of plants).



$$\Delta H = -2860 \text{ kJ mol}^{-1}$$

### Classification:

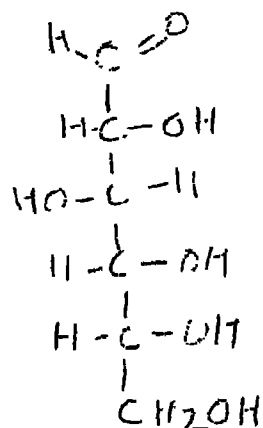
Carbohydrates are grouped into two main classes: the sugars and the non-sugars (polysaccharides). Further sugars are classified according to the number of basic units present in their structure.

<u>Carbohydrates</u>	
Sugars	Non-sugars (Polysaccharides)
(Sweet, soluble, crystalline)	$(C_6H_{10}O_5)_n$
	(Tasteless, insoluble, amorphous) Starch,
	Cellulose etc.

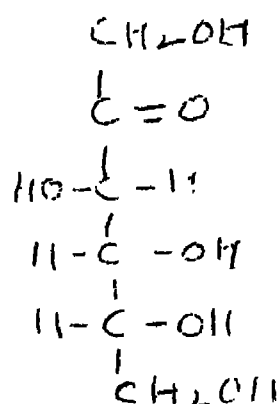
<u>Sugars</u>			
<u>↓</u> <u>Monosaccharide</u>	<u>↓</u> <u>Disaccharide</u>	<u>↓</u> <u>Trisaccharide</u>	<u>↓</u> <u>etc.</u>
(Glucose, Fructose, Galactose)	(C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> ) sucrose, maltose lactose.	C <sub>18</sub> H <sub>32</sub> O <sub>16</sub> Raffinose.	

### Monosaccharides :

Carbohydrates containing 3 to 7 carbon atoms are called simple sugars or monosaccharides. Common monosaccharides contain five carbon atoms (a pentose) or six carbon atoms (a hexose). Monosaccharides are either polyhydroxy aldehydes (e.g., Glucose) or polyhydroxy ketones (e.g., fructose). Sugars containing an aldehyde group (  $\text{-}\overset{\text{H}}{\underset{\text{H}}{\text{C}}}\text{-}$  ) are collectively called aldoses while sugars containing ketonic (  $\text{C}=\text{O}$  ) group are referred to as ketoses. Thus, glucose is referred to as an aldohexose while fructose is an example of ketohexose.



Glucose  
An aldohexose



Fructose  
A ketohexose

### Open chain structure of monosaccharides.

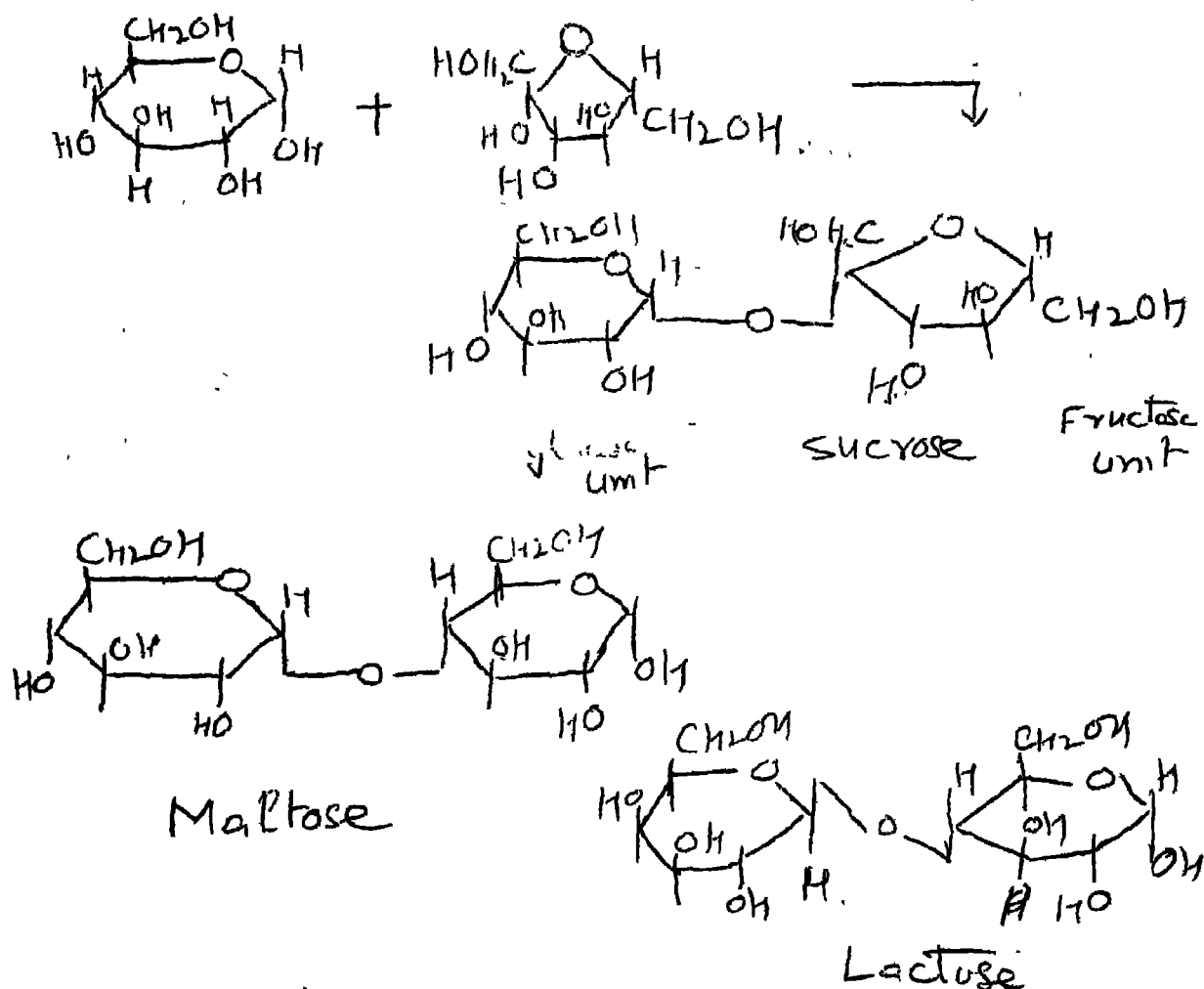
They also exist in cyclic structures.



All the monosaccharides are soluble in water, decompose on heating and have a sweet taste. They show the reactions of both the carbonyl ( $C=O$ ) and hydroxyl ( $-OH$ ) groups.

### Disaccharides:

In disaccharides two simple sugars are joined by a glycosidic linkage by the elimination of water between the aldehyde group of one sugar and the hydroxy or ketonic group of the other (the two monosaccharides need not be the same).



They can be hydrolyzed by enzyme action or by boiling with dilute mineral acids to the constituent monosaccharides. Lactose is found in the milk of all animals. Cow's milk contain 4-5% and human milk 6-7% lactose.

LIPIDS

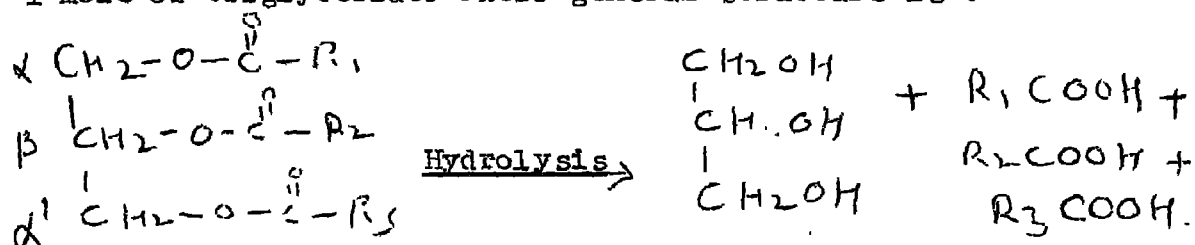
Lipids are an important class of chemical compounds which occur in plant and animal tissues. They are classified together because of their common solubility in organic solvents like ether, petroleum ether and chloroform, and their insolubility in water. In the broad sense, lipids are defined as esters of fatty acids and related compounds. Generally the lipids are classified as simple, Compound or derived.

1. SIMPLE LIPIDS :-

The simple lipids are esters of fatty acids with various alcohols.

a) FATS AND OILS

Fats and oils or neutral lipids are triglycerides, which on hydrolysis release 3 moles of long - chain fatty acids and 1 mole of triglyceride. Their general structure is :



triglyceride

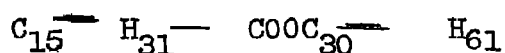
glycerol

Fatty acids

Triglycerides exist in the solid or liquid form depending on the nature of the constituent fatty acids. Triglycerides which are solid at 20° are known as fats and those which are liquid at 20°C are known as oils. Oils contain a large proportion of unsaturated fatty acids such as oleic, linoleic, or linolenic acid with low melting points whereas fats contain a high proportion of saturated fatty acids such as palmitic and stearic acids, of higher melting points. Therefore, depending upon the temperature, any fat can be an oil and vice versa. The term oil introduces some additional implications in that there are oils originating from petroleum, such as mineral, fuel and lubricating oils, as well as essential oil which are important in the

field of flavour and perfumery. Although there is some relation between the lipids and the petroleum oils, based on solubility characteristics and the presence of trace amounts of hydrocarbons in some lipids, the subjects are distinctly different fields of study. The same is true of the lipids and essential oils.

b) WAXES : They are esters of long chain fatty acids with long chain monohydroxy alcohols. For example beeswax.

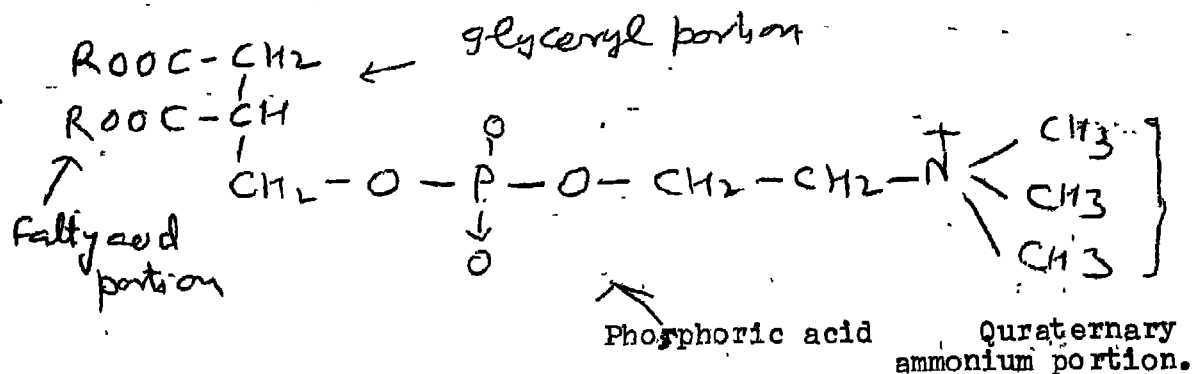


1. COMPOUND LIPIDS :

Compound lipids are similar to the simple lipids with the exception that they contain other components in addition to alcohol and acids. This group includes phospho lipids and glycolipids. In these lipids two of the hydroxyl groups of the glycerol are joined to fatty acids in true fats, but the third group is joined with other chemical substances. They are important components of living cells. Example of compound lipids are.

a) PHOSPHOLIPIDS :

On hydrolysis they yield fatty acids, glycerol, phosphoric acid, and a nitrogen base.



b) GLYCOLIPIDS :

Glycolipids, also known as cerebrosides, contain nitrogen but no phosphorus, and on hydrolysis they yield fatty acids and usually galactose.

### 3. DERIVED LIPIDS :

The derived lipids are substances that are obtained from simple and compound lipids and that have the general characteristics of lipids. In this category are the fatty acids, alcohols hydrocarbons and nitrogens<sup>CU</sup> bases.

### 4. STERIODS :-

Steriods are compounds possessing a phenanthrene structure. They are crystalline solids at ordinary temperatures. Cholesterol, bile salts, vitamin D<sub>2</sub> and various hormones have the steroid nucleus. They are classified with lipids because of their solubility in fat solvents. They differ in physiological properties.

### FATTY ACIDS

Fatty acids are usually open-chain carboxylic acids. Naturally occurring fats usually contain even numbers of carbon atoms in the fatty acids portion of their molecules. Many fats contain fatty acids with as many as 18 carbon atoms in their molecules. Some of the principal fatty acids found in food and other common plant and animal substances are listed in the table below:-

TABLE : FATTY ACIDS OCCURRING IN NATURAL FATS

Name	Chemical formula	Occurrence
Butyric acid	$\text{CH}_3(\text{CH}_2)_2 \text{COOH}$	Butterfat
Caproic acid	$\text{CH}_3(\text{CH}_2)_4 \text{COOH}$	Butterfat
Caprylic acid	$\text{CH}_3(\text{CH}_2)_6 \text{COOH}$	Butterfat
Capric acid	$\text{CH}_3(\text{CH}_2)_8 \text{COOH}$	Butterfat coconut oil.
Lauric acid	$\text{CH}_3(\text{CH}_2)_{10} \text{COOH}$	Coconut oil
Myristic acid	$\text{CH}_3(\text{CH}_2)_{12} \text{COOH}$	Butterfat, Coconut oil

Palmitic acid	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$	Butterfat, lard
Stearic acid	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$	Butterfat, lard Cottonseed oil
Arachidic acid	$\text{CH}_3(\text{CH}_2)_{18}\text{COOH}$	Peanut oil
Oleic acid	$\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	Lard, peanut oil, Butterfat.
Linolenic acid	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\overset{\text{-CH}_2}{\text{CH}}\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	Corn oil Cotton seed oil soybean oil
Linolenic acid	$\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	Linseed oil
Arachidonic acid	$\text{CH}_3(\text{CH}_2)_4-\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_3\text{COOH}$	

From the table note three general characteristics of these fatty acids :

1. They have an even number of carbon atoms.
2. They have one COOH group.
3. They may be saturated or unsaturated compounds.

The hydrocarbon portion of the unsaturated fatty acid molecule may have 1 to 4 carbon-to-carbon double bonds and this accounts for characteristic differences in the chemical behaviour of saturated and unsaturated fats. Oleic acid has 1, linoleic 2, linolenic 3, and arachidonic 4. Polyunsaturated fatty acids containing more than one double bond cannot be synthesized in the body and they are known as essential fatty acids, and must be supplied in the diet. Linoleic and arachidonic acids are in this group, and both are essential fatty acids.

#### Physical Properties of Fats :-

1. Pure fats are odorless and colorless.
2. They exist as solids or liquids.

Most of the saturated fats are solid, whereas most unsaturated fats are liquid.

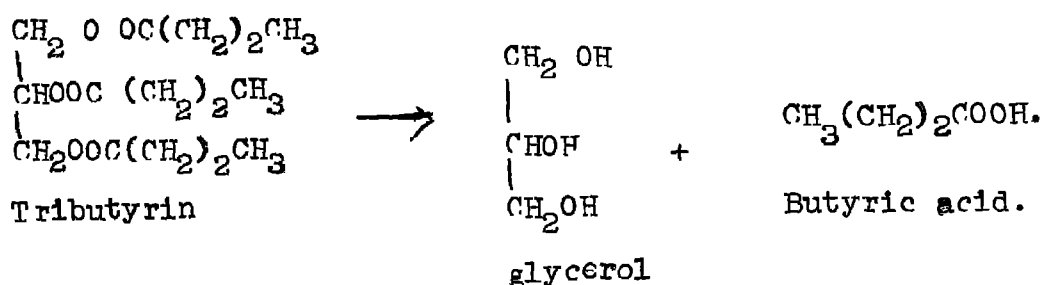
3. They are soluble in chloroform, ether, carbon tetrachloride and other organic solvents, and they are insoluble in water.
4. They are lighter than water.
5. When mixed with water and agitated, they form temporary emulsions.

### Chemical Properties of Fats.

The structure of the fat molecule determines its chemical properties, and since glyceride possesses ester linkages, they can be hydrolysed and saponified. Those with alkene linkages also form addition products.

### Hydrolysis :

Fats, in the presence of appropriate enzymes, acids, bases, or super heated steam hydrolyses to fatty acids and glycerol. In rancid butter the odor and taste are due to the liberation of butyric acid from the butyric ester. This is known as hydrolytic rancidity.



### Saponification:

When fats are hydrolysed by boiling in sodium or potassium hydroxide, the glycerol is liberated, and the fatty acid portion is free to combine with the sodium or potassium ions to form an inorganic ester or soap.



- Formation of Soap

Sodium oleate

Glycerol

: Q :

The Saponification number, (one way of identifying the size of the fat molecule,) is the number of milligrams of potassium hydroxide required to saponify one gram of a fat.

Iodine number :

The iodine number is the grams of iodine absorbed by 100 grams of fat under specified conditions. This is the measure of unsaturated linkages present in a fat.

Reichert-meissl (RM) Value :-

This value is the number of millilitres of 0.1N alkali solution required to neutralize the volatile, soluble fatty acids distilled from 5 grams of fat under specified conditions. This is mainly due to butyric and caproic acids.

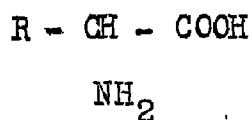
Polenske Value :-

This value is the number of millilitres of 0.1N alkali solution required to neutralize the volatile and insoluble fatty acids distilled from 5 grams of fat under specified conditions. This is mainly due to caprylic and capric acids.

Proteins

The word protein is derived from a Greek word 'proteios' meaning "of first importance". They are vital for maintenance and growth of life. Basic elements present in proteins <sup>are</sup> carbon, hydrogen, oxygen, nitrogen and generally sulfur. Some proteins also have small amounts of phosphorus, or iron. For example casein, protein of milk has phosphorus, haemoglobin, protein of blood has iron. A little over one sixth of the average protein is nitrogen.

The building units for all proteins are amino acids. Amino acids are organic acids that contain an amino ( $-NH_2$ ) group, as well as a carboxyl ( $-COOH$ ) group. The remainder of the molecule is often quite complex. More specifically, they are  $\alpha$ -amino acids and have the general formula :-



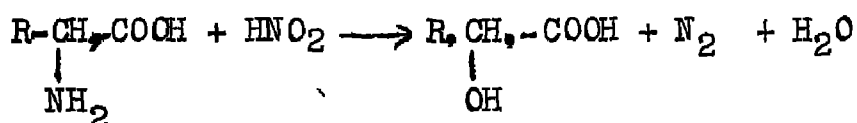
The group R can be hydrogen or any other group. When the 'R' group is hydrogen, the corresponding amino acid is glycine. All other amino acids, except glycine, thus contains an asymmetric carbon atom, a carbon atom to which four different groups are attached. Since compounds possessing an asymmetric carbon atom rotate the plane polarized light and are thus optically active, all amino acids, except glycine are optically active. At least twenty different amino acids have been recognised as constituents of naturally occurring proteins. Some of these amino acids must be supplied from



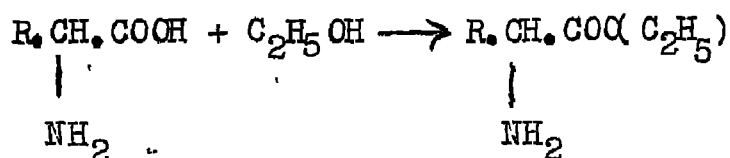
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the food since they can not be synthesized by the body. They are thus called essential amino acids and are lysine, tryptophan, phenyl alanine, leucine, Isoleucine, threonine, methionine, valine, Arginine and Histidine. Other representative amino acids found in proteins are glycine, Alanine, Aspartic acid, glutamic acid, Proline, Tyrosine, Cysteine, Cystine, serine and hydroxy proline.

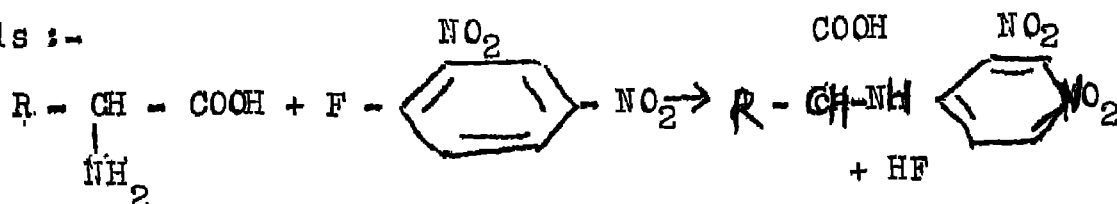
Any organic compound having a carboxyl ( $-\text{COOH}$ ) group behaves as an acid. Similarly, any organic compound having an amino ( $-\text{NH}_2$ ) group behaves as a base. Since amino acids have both the Carboxyl ( $-\text{COOH}$ ) as well as amino ( $-\text{NH}_2$ ) group, they can behave both as an acid as well as a base. They are thus called Zwitterions. Amino acids react with Nitrous acid ( $\text{HNO}_2$ ) to liberate nitrogen gas.



They form esters with alcohols.



A compound 1-Fluoro -2,4 - dinitro benzene (FDNB) known as Sanger's reagent forms yellow coloured compound with amino acids :-

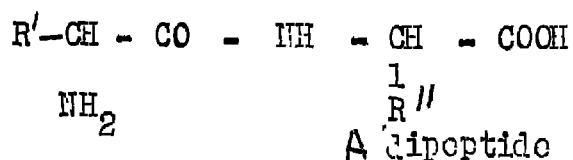
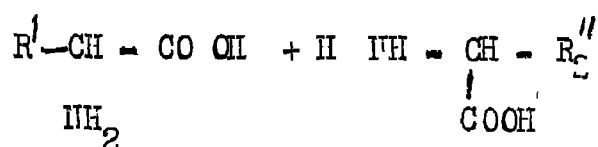


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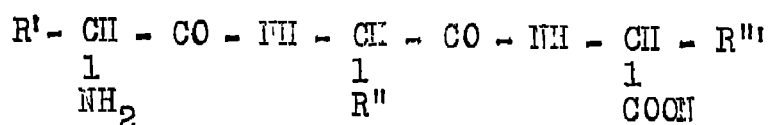
Amino acids react with ninhydrin to form a blue coloured compound.

### Peptide linkage

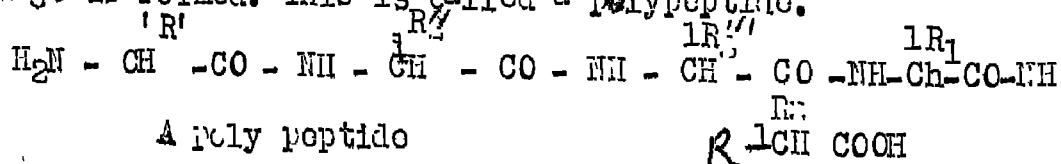
Two amino acids can be joined together by a peptide linkage which is formed when amino group of one amino acid reacts with the carboxyl group of another amino acid.



When two amino acids are joined together by a peptide linkage, the compound formed is called a dipeptide. Similarly when another amino acid is joined by a peptide linkage to a dipeptide, a tripeptide is formed. This process of addition of amino acids can go on till a long chain of amino acids joined by peptide



linkage is formed. This is called a polypeptide.



### Structure of Proteins

Proteins may exist as a simple polypeptide or may form a complex structure.

### Primary structure of proteins

The polypeptide chain in proteins is referred to as the **primary** structure of proteins.

### Secondary structure of proteins

Polypeptide chain of the protein exist as random coils or adopt a helical or sheet structure. These arrangements of polypeptide chain in proteins are referred to as the secondary structure of proteins. The secondary structure of proteins is stabilized by the formation of weak bonds called hydrogen bond between the carbonyl (-CO-) and amide (-NH-) groups between different amino acids of the polypeptide chain.

### Tertiary structure of proteins

Some proteins like globular proteins have much more complex structure than the secondary structure. The structure may be stabilized by covalent bonds, ionic bonds, salt linkages etc. Such a structure is referred to as the tertiary structure of proteins.

### Quaternary structure of proteins

When more than one protein units form a complex structure it is called the quaternary structure of a protein. Native hemoglobin, the protein present in blood, for example, has four polypeptide chains as two pairs of  $\alpha$ - and  $\beta$ . Chains joined together to form one complete molecule.

### Classification of proteins

#### 1. Simple proteins

The proteins which are made up only of amino acids are called simple proteins.

## 2. Conjugated Proteins

Some proteins occur united with other non-proteins molecules like carbohydrates, nucleic acids etc. in nature. Such proteins are called conjugated proteins.

### Properties of Proteins

- (i) Colloidal Character :- The principal physical characteristic of all soluble proteins is that they form colloidal solution.
- (ii) Adsorption of Water :- Proteins have the capacity to adsorb large quantities of water.
- (iii) Electrical Charge :- Most proteins carry a positive charge in acid solution and a negative charge in neutral or alkaline solution.

## II. Chemical Properties

- (i) Amphoteric Property :- Proteins can act both as an acid as well as a base.
- (ii) Hydrolysis :- When proteins are boiled in presence of acid or alkalies, they are hydrolysed and give rise to amino acids.
- (iii) Denaturation :- When soluble proteins are heated, a change takes place in the nature of the protein which makes the protein less soluble than the original protein. The protein usually coagulates. The biological activity of the protein is destroyed. This is called denaturation of proteins. Denatured proteins get hydrolysed more readily.

When egg is boiled, its proteins are coagulated because of its proteins getting denatured. When a protein is denatured, its structure changes from a regular structure to random structure due to rupture of hydrogen bonds. Proteins can be denatured also by salts of heavy metals like  $\text{Ag}^+$ ,  $\text{Cu}^{++}$ ,  $\text{Pb}^{++}$ ,  $\text{Hg}^{++}$  etc. strong inorganic acids or bases, alkaloidal reagents and organic acids and ethyl alcohol.

(iv) Salting Out

When various salts in solid form e.g.  $(\text{NH}_4)_2\text{SO}_4$ ,  $\text{Na}_2\text{SO}_4$ ,  $\text{MgSO}_4$  or  $\text{NaCl}$  are added to a protein in solution, certain proteins are precipitated unaltered in composition. This process is known as salting out of proteins.

(v) Colour reactions

(a) Xanthoproteic test

When a protein is dissolved in concentrated  $\text{HNO}_3$  and heated, the solution will turn yellow changing to orange upon addition of  $\text{NaOH}$ . A positive xanthoproteic test depends upon the presence of tyrosine and phenylalanine in the protein.

(b) Millons test

When a mixture of mercuric and mercurous nitrates is added to a protein and they are heated, a red precipitate is formed dependent upon the presence of tyrosine in the protein.

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(c) Bidrot test

When a few drops of NaOH or KOH are added to a protein solution followed by a few drops of dilute  $\text{CuSO}_4$  solution a violet colour develops. This test is given by practically all proteins.

(d) Hookins - Cole test

Equal quantities of the solution of protein and glyoxylic acid ( $\begin{smallmatrix} \text{CHO} \\ | \\ \text{COOH} \end{smallmatrix}$ ) are mixed in a test tube. A layer of concentrated  $\text{H}_2\text{SO}_4$  is carefully placed under the mixture. A violet ring at the juncture of two liquids develops. This test is dependent upon the presence of tryptophan in the protein.

## Enzymes

Chemical changes taking place within the body invariably require the presence of catalysts to speed up the rates of reactions at body temperature and pH of the body fluids. These catalysts produced by living cells in plants and animals are called enzymes.

### Nomenclature

The substance upon which an enzyme works is called its substrate. The enzymes are usually named after their substrate with the name ending in 'ase'. For example an enzyme that acts on "lipids". Some of the enzymes are designated according to the type of reaction they catalyse. Yet others have retained the names originally given to them before the present system of nomenclature was adopted.

### Chemical nature

All enzymes are protein in nature. Excessive heat, alcohol, salts of heavy metals and concentrated inorganic acids inactivate the enzymes.

### Properties of enzymes

#### Specificity

Some enzymes will act only on one specific compound e.g. Urease will act only to hydrolyse urea and no other compound. Some enzyme will act only on one stereo isomeric form of a compound e.g. Lactic dehydrogenase will act on L-lactic acid but will not act on D-lactic acid. A large group of enzymes however show less specificity and will act on a functional group, others on one type of linkage.

#### Enzyme activity

The activity of an enzyme is affected by many factors. There are thus certain conditions under which they work best. These conditions are called the optimum conditions. The optimum temperature for enzymes functioning in the animals is generally near that of body temperature. Some vegetable enzymes have quite a different optimum temperature. The enzyme urease from jack bean e.g. has an optimum temperature of about 10°C. Some enzymes act best in neutral medium, some best in an alkaline, while others prefer an acid medium.

### Mode of action of enzymes

Enzyme and its substrate combine to form a complex which then breaks up to yield the reaction products and the enzyme.

Enzyme + Substrate  $\rightarrow$  Enzyme — Substrate complex

Enzyme-substrate complex  $\rightarrow$  Reaction products + Enzyme.

The enzyme is free for further action. Thus a small amount of enzyme can activate large number of molecules at a very rapid rate. For example, it has been calculated that approximately 3,00,000 molecules of  $H_2O_2$  can be broken down every minute by a molecule of the enzyme, catalase.

### Activation of Enzymes

#### Proenzymes or Zymogens

Some enzymes are secreted in an inactive form called proenzyme or zymogen which requires specific conditions before the active enzyme is produced. Pepsinogen secreted in the stomach for example is inactive. HCl converts a small quantity of pepsinogen to active enzyme, pepsin which converts the remainder of pepsinogen to pepsin.

In order for some other enzymes to function there must be present in the molecule specific non-protein groups. If these groups are organic, they are called Coenzymes. If they are inorganic they are called Activators. The enzymes with its coenzyme is called holoenzyme and without it is called Apoenzyme. Thus

Coenzyme + Apoenzyme  $\rightarrow$  Holoenzyme.

### Inhibition of Enzymes

The compounds which have the ability to block the normal functioning of an enzyme are called Inhibitors. A specific inhibitor acts by combining with the enzyme or its activator thus preventing the enzyme from acting. A non-specific inhibitor acts by denaturing the enzyme. A specific inhibitor is called a Competitive inhibitor. If inhibition can be decreased by increasing the concentration of the substrate. If the inhibition can not be decreased by increasing the concentration of the substrate, it is called non-competitive.



### Classification of the Enzymes

The enzymes can be classified into :

1. Hydrolases - They split compounds with the help of  $H^+$  and  $OH^-$  groups of water.
2. Decarboxylases - They release  $CO_2$  from compounds.
3. Transferases - They transfer functional group from one compound to another.
4. Isomerases - They create isomers by rearrangement of atoms within the substrate.
5. Oxidases - They transfer hydrogen atoms.
6. Adding enzymes - They involve addition or removal of water, ammonia  $CO_2$  or more complex molecules.

## Vitamins

Vitamins are essential dietary factors whose absence in the diet results in a deficiency disease. They are required in minute amounts, but the body can not synthesize them even in these minute amounts.

Vitamins are classified into two categories :

Fat soluble vitamins e.g. vitamin A, D, E and K.

Water soluble vitamins e.g. Vitamins B Complex and Vitamin C

### Fat Soluble Vitamins

#### Vitamin A

Vitamin A must be supplied by the diet. If sufficient Vitamin A is not present in the diet, one suffers from night blindness which means inability to see in dim light. It is also necessary for normal growth. In its absence membranes become dry.

Vitamin A is soluble in fat and fat solvents but is insoluble in water. It is unstable in air, light and in the presence of rancid fat. It is not destroyed when food is subjected to moderate heat. Vitamin A is stored mainly in liver.

#### Vitamin D

This vitamin is found in fish oils, eggs and yeast. It is produced when skin of the body is exposed to sunlight. Deficiency of Vitamin D in infants and young children results in a disease called rickets in which bones are deformed. In adults calcium salts are lost from the bones.

#### Vitamin E

This vitamin is believed to be necessary for normal reproduction. Its absence may cause habitual abortion and sterility.

#### Vitamin K

The deficiency of this vitamin results in an increase in the clotting time of blood. It is normally present in sufficient quantities in the average diet and also available as a synthetic preparation, menadiolone, which is used clinically to prevent and control hemorrhage in newborn child and may be given to mother prior to infant's birth. Vit K is fat soluble, stable to heat. It is however unstable to light.

### Water soluble Vitamins

Water soluble vitamins include Vitamin B complex and Vitamin C. Vitamin B complex further includes Vitamin B<sub>1</sub> (Thiamine), B<sub>2</sub> (Riboflavin) B<sub>6</sub> (Pyridoxine) B<sub>12</sub> (Cyanocobalamin), Nicotinic acid (Niacin), Pantothenic acid, Folic acid, and Biotin.

#### Vitamin B<sub>1</sub> (Thiamine)

Deficiency of vitamin B<sub>1</sub> causes a disease called beriberi in which nervous system is affected. Lack of appetite, loss of weight, muscular weakness, constipation and fatigue result if the supply of this vitamin through diet is low. This vitamin is not stored in the body to any extent. Vitamin B<sub>1</sub> is white crystalline and water soluble. It is relatively stable in the dry form. Vitamin B<sub>1</sub> is destroyed in cooking since it is inactivated on heating under neutral or alkaline conditions. Green vegetables should be cooked with as little water as possible. Addition of Na<sub>2</sub>CO<sub>3</sub> to preserve the green colour of vegetables further reduces their vitamin B<sub>1</sub> content.

#### Vitamin B<sub>2</sub> (Riboflavin)

Deficiency of Vitamin B<sub>2</sub> in the diet results in characteristic lesions on the tongue lips and in corner of the mouth and ocular disturbances with burning, itching and a sensation of roughness in the eyes. It is found in egg yolk, rice polishings, milk and vegetables. It occurs as a fine, orange yellow needle like crystals or powder, slightly soluble in water, forming a yellow green fluorescent solution. It is destroyed by light and alkalies, cooking, roasting and frying.

#### Vitamin B<sub>6</sub> (Pyridoxine)

Prolonged deficiency of this vitamin causes nervous disturbances and convulsions. It occurs in cereals, egg yolk and meat. It is stable to acids, alkalies and heat.

#### Vitamin B<sub>12</sub> (Cyanocobalamin)

Deficiency of vitamin B<sub>12</sub> causes 'anaemia'. Vitamin B<sub>12</sub> is a complex, red, crystalline substance containing cobalt and phosphorus. Liver extract is a rich source of this vitamin.

### Nicotinic acid (Niacin)

Deficiency of this vitamin causes a disease called pellagra, which is characterized by sore, fiery tongue, abdominal pain and diarrhoea, and mental disorders. It occurs as white, odorless needles or powder. It is resistant to heat, light, oxidation, acid and alkalis and is one of the most stable of the vitamins.

### Pantothenic acid

It has been suggested that this vitamin may be an anti-gray-hair factor in man. It is stable to heat in neutral solutions.

### Folic Acid

Deficiency of this vitamin causes some type of anaemia. It is a yellow compound slightly soluble in water and is stable to heat except in an acid medium.

### Biotin

Deficiency of biotin causes loss of hair, dermatitis and loss of muscle control. It is present in liver, kidney, milk, molasses and egg yolk.

### Vitamin C (Ascorbic acid)

Deficiency of this vitamin leads to scurvy, a disease characterized by sore spongy gums, loosening of teeth and painful joints. This vitamin is present in fresh vegetables and fruits e.g. fresh citrus fruits, raw tomatoes etc. Vitamin C occurs as a colourless crystalline substance slightly acid in taste. It is water soluble, sensitive to alkalis and easily oxidised. It is regarded as least stable of the vitamins. Cooking the vegetables for a long time and cutting it into small pieces destroys the vitamin.

## HORMONES

Human body has certain ductless glands also called the endocrine glands which secrete minute amounts of complex chemical substances called hormones. These hormones are secreted directly into the blood stream and regulate body processes and are responsible for sex characteristics.

### Hormones of the pituitary gland

The pituitary, a small gland weighing less than 0.75 gms, lies at the base of the brain, it is divided into three distinct hormone producing areas viz the anterior, intermediate and posterior lobes..

### Hormones of the Anterior lobe

----- Important hormones secreted by the Anterior lobe are :

#### I. Gonadotropins

They have stimulating effect on gonades or sex organs.

They are :

##### (i) The follicle-stimulating hormone (FSH)

It stimulates the growth and maturation of follicles of the ovary in female and influences the maturation of spermatozoa in male.

##### ii) Luteinizing hormone (LH)

It stimulates formation of corpus luteum and its hormone progesterone. In males it stimulates interstitial cells of testes to increase their production of testosterone.

##### iii) Prolactin

It initiates and maintains lactation

#### II. Growth hormone

An excess of this hormone in childhood and adolescence causes gigantism. A deficiency of the hormone in childhood results in dwarfism.

#### III. Thyrotropic hormone (TSH)

This hormone is necessary for normal thyroid development and activity.

#### IV. Adrenocorticotrophic Hormone (ACTH)

This hormone stimulates the cortex of the adrenal gland to secrete cortisone and related substances.

#### Hormones of the Posterior Lobe

The posterior lobe secretes at least two hormones :

##### i) Vasopressin

This hormone raises blood pressure and reduces the output of urine.

##### ii) Oxytocin

This hormone contracts smooth muscle such as that found in the uterus.

#### Hormones of the Intermediate Lobe

The intermediate part of the pituitary produces a hormone called melanophore stimulating hormone (MSH) which stimulates pigment containing cells.

#### Hormones of the thyroid gland

The thyroid is a small, highly vascular gland, with two lobes, connected by a strip of tissue. A lobe lies on each side of the trachea. It secretes a hormone called thyroxine. If thyroid gland fails to develop in early life, child does not develop normally, either physically or mentally. Goiter, or enlargement of the thyroid gland prevalent in regions, due to lack of iodine in drinking water can be prevented by adding an iodide in table salt or drinking water.

#### Hormones of the Parathyroids

Parathyroids are four small glands, two of which are embedded in the thyroid and two others lie close to it. The hormone secreted by them is parathormone which regulates the level of calcium and the level of calcium and phosphorus in the blood. Complete removal of the parathyroid tissues causes tetany and death. Over activity of the glands makes the bones fragile and may lead to formation of kidney stones.

### Hormones of the Pancreas

This gland produces two hormones. They are

#### (i) Insulin

This hormone controls the concentration of glucose in blood. In its absence glucose is secreted in urine and the individual suffers from the disease called diabetes mellitus, this can be cured with insulin.

#### (ii) Glucagon

This hormone increases the level of glucose in blood.

### Hormones of the Adrenal glands

The adrenal gland is situated on the upper pole of each kidney. The inner portion of the gland is called medulla and the outer portion cortex.

#### Hormones of the medulla

It secretes two hormones called epinephrine and norepinephrine. Epinephrine is an emergency hormone since it responds in time of increased energy requirement and of emotional stress or tension such as anger or fear and also cold. Its secretion results in increase in blood sugar, blood pressure, and blood circulation as well as relaxation of smooth muscle. Norepinephrine differs from epinephrine that it does not increase blood sugar or relax smooth muscle.

#### Hormones of the cortex

Hormones of the cortex are concerned with metabolism of carbohydrates, regulation of sodium and potassium balance in the body and sex characteristics.

If these hormones are deficient or absent, insulin function is disturbed. Excretion of sodium increases and potassium content of the blood is greatly increased. Blood volume is also affected. When these hormones are secreted in higher concentration, body retains higher amounts of sodium and excretes large amount of potassium. In women, it causes marked masculine characteristics.

-:24:-

Hormones of the cortex increase body's resistance to intense heat or cold, infections and stress conditions. Some of them are effective in reducing inflammation in arthritis and other conditions such as allergies. Some skin conditions and eye infections are controlled by their use.

### Sex hormones

They are concerned with development of sex organs and of the secondary sex characteristics. They are produced in the female by ovaries and are secreted in the males by testes.

### Hormones of the ovary

The three hormones called estrone, estriol and estradiol are concerned with changes necessary to maintain menstrual cycle. The hormones called progesterone prepares uterus for implantation of ovum, if it gets fertilized. It is also responsible for the maintenance of pregnancy and development of mammary glands. Relaxin, a hormone produced by ovaries, uterus and placenta relaxes pelvic ligaments during childbirth.

### Hormones of the testes

Testes produce a hormone called testosterone that is concerned with the development of male sex organs and secondary sex characteristics.



### Fermentation

Fermentation, derived from 'fermentaire' which means 'to boil' refers to the chemical changes brought about through the agency of micro-organisms - organisms which can not be seen with the naked eye, but can be seen through a microscope. During fermentation, micro-organisms grow by deriving their nutrients from the medium in which they grow and in turn produce chemical compounds called as "fermentation products". Fermentation products like ethyl alcohol, lactic acid, methane gas, antibiotics etc. are harmful like toxic substances called toxins.

#### Factors affecting fermentation

##### Several factors affect fermentation

##### (1) Nature of the medium

Fermentation depends upon the chemical nature of the medium which is fermenting, The medium may thus be rich in carbohydrates, proteins, fats etc. and nature of the micro-organisms bringing about the fermentation also depends to a very large extent on the chemical nature of the medium. Physical nature of the medium also affects fermentation e.g. whether the medium is <sup>S</sup>semisolid or liquid.

##### (2) pH of the medium

Fermentation is also effected by the pH of the medium i.e. whether the medium is acidic, neutral or alkaline. The micro-organism bringing about the fermentation grow best and produce fermentation products at a certain pH (the measure of acidity or alkalinity, pH below 7.0 meaning acidity and between 7 to 14 meaning alkalinity) called the optimum pH. pH of the medium above or below optimum decreases the rate of fermentation.

##### (3) Temperature

Like pH, fermentation has also an optimum temperature of the temperature at which the fermentation proceeds at its maximum rate. Above and below this temperature, rate of fermentation decreases.

#### (4) Oxygen

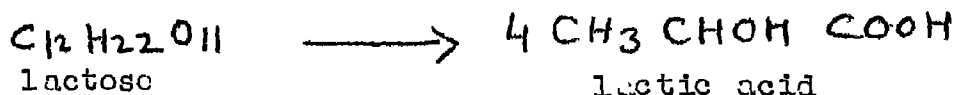
The concentration of oxygen in the medium also affects the rate of fermentation.

#### Nature of fermentation

Micro-organisms are widely distributed in nature being present in air, water, soil, plants, animals etc. and being about fermentation of any natural substrate they come across. Some of these fermentations have been made use of since ancient times.

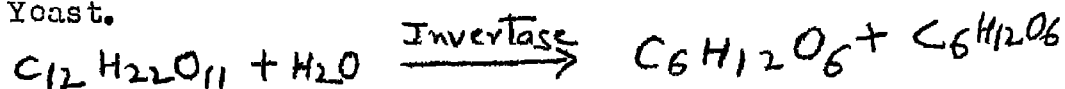
#### Souring of milk

When milk is converted into dahi, the micro-organisms known as lactic acid bacterial convert the sugar present in milk called lactose into lactic acid which is responsible for the sour taste of Dahi.



#### Production of ethanol

Molasses, a dark brown, viscous liquid, a byo product of sugar industry contains lots of sugar i.e. sucrose and is used as a raw material to convert sucrose into ethyl alcohol by fermenting it with a micro-organism called yeast. During fermentation, the sucrose in molasses is first converted into glucose and fructose by the enzyme invertase present in the Yeast.



Glucose produced is further converted into a ethyl alcohol with the evolution of  $\text{CO}_2$  by the enzyme Zynase present in the Yeast.

Silage making: Preservation of forages is carried out by converting them into silage, by fermentation. The process involves breakdown of carbohydrates proteins etc. of forages by micro-organisms in the absence of oxygen.

FOOD COLOURS AND DYES

Colours and dyes are mostly used for dyeing the fabrics but some of these are also used for colouring the foods.

Apart from the natural food colours obtained from the plant and animal sources, many of the synthetic organic dyes (coal tar dyes) which belong to the chemical group of diazo compounds are widely used as food colours. The use of these synthetic dyes as colouring matter is very common in drug industry. Example of these synthetic dyes include the following: Ponceau 4R, Carmoisine, Amaranth, Erythrosine BS, red 6B, fast red E, Red FB, Tartarazine, Sunset yellow FCF, Indigo carmine, Black PN etc.

Although these well tested dyes have been shown to be harmless but there is a tendency by the food technologists to restrict their use and to employ rather naturally occurring pigments such as carotene, annatto etc. in their place.

Food colour exerts a remarkable influence on people's attitude towards liking and disliking of the food, irrespective of the nutritive value and freshness of the food. The addition of colouring matter to foods has several objectives, some desirable, others undesirable. These are as follows :

- (i) to increase the attractiveness of the food
- (ii) to achieve the uniformity of the product
- (iii) to conceal damage or inferiority

The addition of colouring matter to foods is controlled by the prevention of food Adulteration (PFA) rules, 1955 (as amended) which gives a list of compounds which may be used. Those most commonly used are the permitted water soluble coal-tar colours. It should be borne in mind, however, that it is not permissible to add colour to many foods, such as some dairy product, tea and coffee, and unprocessed flesh foods, fruits, and vegetables.

What are coal tar dyes?

### Dyes:

Chemical substances (coloured compounds) which can be employed in such a manner that they will attach themselves to fabrics or surfaces in order to give a colour are classified as dyes. All coloured compounds are not dyes.

For a substance to act as a dye, certain conditions must be fulfilled :

- (i) It must have a suitable colour
- (ii) It must be able to 'fix' itself or be capable of being 'fixed' to the fabric.
- (iii) The fixed dye must have fastness properties: (a) fastness to light; (b) resistance to the action of water, dilute acids and alkalies, various organic solvents used in dry cleaning etc.

Many natural dyes have been known for a long time. These were obtained from animal and vegetable sources. Today, however, practically all dyes are synthetic and are prepared from aromatic compounds, the only source of which was originally coal-tar; and hence the name coal-tar dyes.

### Nomenclature of dyes :

There is no systematic nomenclature of dyes. Many have names that have been given to them by the manufacturers, and so it is not unusual to find a given dye having several names. Generally, each dye has a trade name (or names), and the shade is indicated by a letter, e.g., Y or G = yellow (gold); O = orange; R = red; B = blue. Sometimes the letter is repeated, the number of letters indicating roughly the intensity of the colour, e.g. methyl violet<sup>6</sup> B is a very deep purple (close to blue). Sometimes the letters have other meanings, e.g. alizarin blue D; here the D means that this dye is a direct cotton colour; fuchsin, S, the S indicating that the dye is an acid (sancer) colour. The letter F is often used to indicate that the dye is fast to light.

To avoid difficulties, each dye is now assigned its individual colour number.

### Classification of Dyes

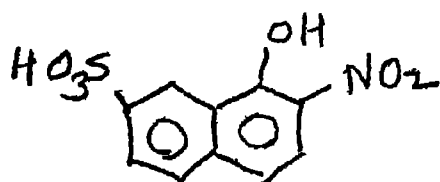
Dyes can be classified in two ways :

- (1) According to their chemical constitution.
- (2) According to their application to the fibre.
- (1) Classification according to chemical constitution

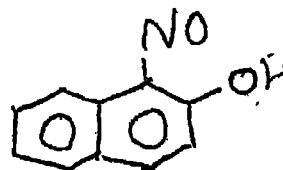
This classification of dyes includes the following main types:-

#### (1) Nitro and Nitroso Dyes

The  $\text{NO}_2$  and  $\text{NO}$  groups are chromophores (colour bearing component) in this class of dyes. Examples are :



Naphthol yellow S

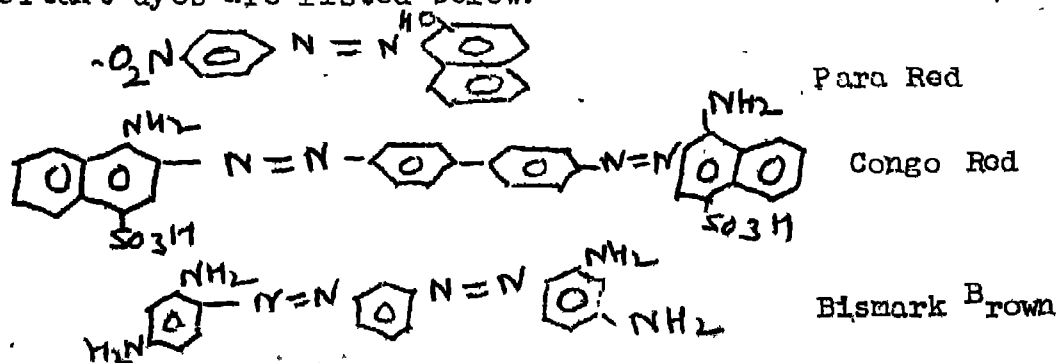


Mordant green 4

#### (ii) AZO dyes

The Azo dyes contain one or more Azo groups ( $-\text{N}=\text{N}-$ ) as the primary chromophore. Azo dyes constitute the largest and most important group of synthetic dyes. They are highly coloured.

A wide range of Azo dyes are available. Some of the important dyes are listed below:



Para Red

Congo Red

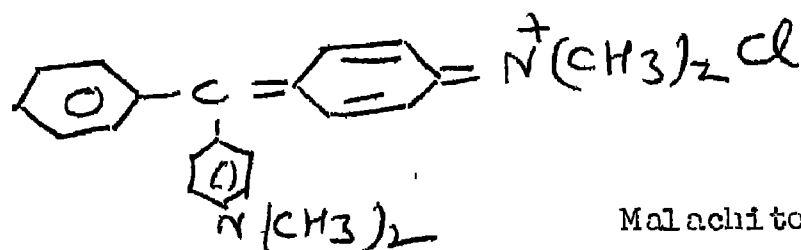
Bismark Brown

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Methyl orange is also an azo dye but it is better known as an acid-base indicator.

(iii) Triarylmethane dyes:

In triarylmethane dyes, central carbon is bonded to three aromatic rings, one of which is in the quinoid form (the chromophore). Malachite green is a typical triarylmethane dye.

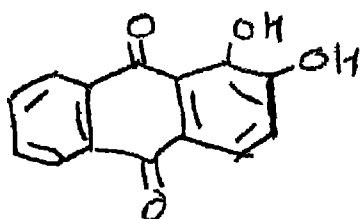


Malachite green

Chenolpthalein is also a triarylmethane dye but it is better known as an acid-base indicator.

(iv) Anthraquinone dyes

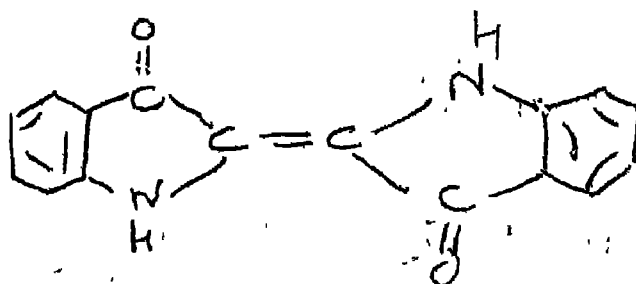
The para quinoid chromophore is present in these anthraquinone type dyes. Alizarin is a typical example



Alizarin

(v) Indigo Dyes:

Indigo is an example of the type of dyes which contain the carbonyl chromophore.

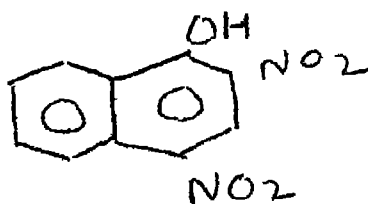


(2) Classification according to application

This classification of dyes includes the following main types :

(1) Direct dyes

A direct dye is a dye that is applied directly to cloth from a hot aqueous solution. Martius yellow is a typical direct dye.



Martius yellow

(ii) Vat Dyes

These dyes are insoluble in water but on reduction with sodium hydrosulphide in a vat form a soluble compound which has a great affinity for cotton and other cellulose fibres. Indigo is a typical vat dye.

(iii) Mordant Dyes:

These dyes have no natural affinity for the fabric and are applied to it with the help of salts e.g. oxides of Al, Cu, Co, or Cr. These salts are called mordants. A fibre such as cotton is first treated with a mordant and then with a dye solution. The mordant forms an insoluble coordination complex between the fibre and the dye, and binds the two. Alizarin is a typical mordant dye.

(iv) Disperse Dyes:

These dyes are insoluble in water but can be dispersed in a colloidal form in water. The fabric is immersed in the colloidal dispersion as the dye. The fine dye particles are absorbed into the crystal structure of the fabric.

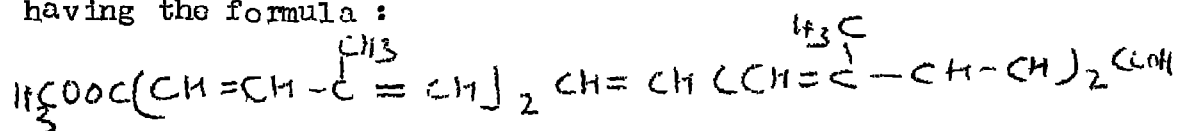
Disperse dyes are used for modern synthetic fabrics such as nylon, orlon, polyesters, and cellulose acetate.

Colouring matters used in dairy industry.

Butter and cheese are permitted to contain the annatto colour. Similarly Ice-cream is also allowed to contain some of the permitted food colours. Carotene is naturally present in cow milk which imparts yellow colour.

What is annatto.

Annatto, the colouring matter used for butter and cheese contains a red-yellow pigment bixin, which is extracted from the seeds of the shrub Bixa orellana. Bixin is a carotenoid having the formula :



It is an acid. The potassium salt of this acid forms the basis of cheese annatto, which is essentially an alkaline solution of this salt. In cheese this coloured salt is bound by the protein. For colouring butter, the pigment bixin is dissolved in oil, from which it passes into butter fat. The pink constituent of cheese becomes more apparent as acidity increases between 6.0 and 4.8. This compound is unsaturated and may be the centre of oxidation and reduction changes. The bleached or pink discolouration is sometimes caused by oxidation of annatto as bleaching has been usually observed in the cracks of cheese. If the milk fat of cheese was replaced by oxidised butter fat of tallowy taint, cheese made from it showed extensive bleaching of annatto. Sulphydryl compounds act as catalysts in these changes.

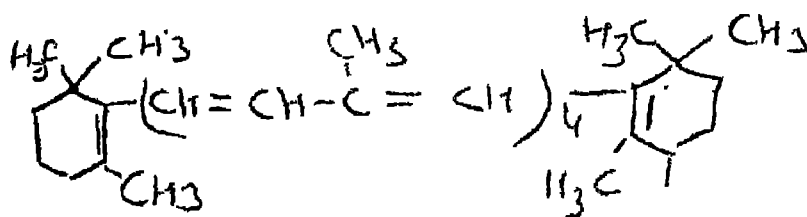
The colour of annatto solutions fades under the influence of light or in the presence of copper and as such should be stored in glass vessels instead of metallic containers.



### Carotene ?

Carotene is a fat soluble yellow colour pigment. - The yellow colour of cow milk is due to carotene. The reddish-yellow colour of carrot is also due to this pigment. Pure carotene has a red brown colour but in very dilute fats solutions it imparts a rich yellow colour. It is not soluble in water and therefore it colours only the fat phase of the milk. The rich yellow colour of cow cream and butter is due to higher fat content containing this pigment.

Carotene is a member of important class of compounds known as carotenoids which include xanthophyll (another yellow pigment of green leaves). Carotene is a precursor of vitamin A and acts as an antioxidant. Carotene is present in three forms i.e. alpha, beta and gamma. Structure of  $\beta$  carotene (predominantly present in milk) is shown below :



$\beta$  Carotene  $C_{40}H_{56}$

One molecule of  $\beta$ -carotene give rise to two molecules of Vitamin A. Buffalo is a efficient convertor of  $\beta$  cartene into Vitamin A in its intestine, where as cow cannot convert it. Therefore the colour of buffalo milk is white as it has only vitamin A and no-carotene in it.

## Preservatives, Adulterants and Neutralizers

### Preservatives:

Preservatives may be defined as chemical substances which when added to food will check the growth of micro-organisms and thus prevent the spoilage of the food. They are added to increase the shelf life of the food. They safeguard the physical properties, chemical composition and original nutritive value of food against the bacterial attack as they are capable of inhibiting or arresting the process of fermentation or decomposition of food by microbial activity.

### Mode of action of preservatives:

The mechanism by which chemical preservatives act has not been entirely elucidated, but it is possible that food which is not heavily contaminated with bacteria may be preserved by chemicals because these chemicals prolong the time (lag phase) of bacterial growth. Interference with chain reactions may be another explanation of the action of chemical preservatives.

However, they are known to possess antiseptic, antifermentative, bacteriocidal, germicidal action. Some of them act as antioxidants, neutralizers, stabilizers & emulsifiers also.

### Classification of preservatives

Chemical preservatives may be classified in a number of ways. For instance, they may be grouped into the followings:

- (1) Inorganic preservatives
- (2) Organic preservatives
- (3) Sweeteners
- (I) Inorganic preservatives

In this group of preservatives, the principal

agents used are as follows :

- ( i) Nitrates and Nitrites
- ( ii) Sulphites and sulphurous acid
- ( iii) Boric acid & Borates
- ( iv) Iodates
- ( v) Free chlorine
- ( vi) Hypochlorites e.g. NaOCl
- ( vii) Peroxides e.g. Hydrogen peroxide.

( 2) Organic preservatives

The principal agents in this group of preservatives are given below :

- ( i) Benzoic acid & its salts
- ( ii) For maldehyde e.g. Formalin which is a 40% solution of formaldehyde
- ( iii) Salicylic acid & its salts
- ( iv) Formic Acid
- ( v) Esters of p-Hydroxybenzoic Acid
- ( vi) propionic acid and its sodium and calcium salts
- ( vii ) Thiourea etc.

( 3) Sweeteners

The principal sweetening agents are :

- ( i) Saccharin
- ( ii) Dulcin.

Many of the other substances like sugar, salt, vinegar, organic fruit acids, wood smoke, alcohol etc. are also used as preservatives but they are not ordinarily categorised as preservatives.

Chemical preservatives may also be classified according to their use or action - namely, as antiseptics, germicides, fungistats, mycostats, antioxidants, neutralizers, stabilizers, emulsifiers, and Coating agents etc.

### Restrictions on the Use of preservatives

The addition of preservatives to food is controlled by the prevention of Food Adulteration (PFA) Rules, 1955 (as amended) under the PFA act, 1954 of the Govt. of India. Under the provisions of these rules, some of the foods are allowed to contain the permitted preservatives upto various prescribed limits. However, addition of these beyond the prescribed limit is a legal offence. Similarly, the addition of preservatives other than those permitted by the food laws is also an offense.

Addition of Preservatives to some of the natural foods, for example, milk is strictly prohibited because milk is a basic food and as such it should be free from chemical preservatives. However, preservation of such basic foods should be achieved through improved methods of production and processing rather than by the addition of preservatives. The use of preservative makes it possible to sell even such foods which may be unfit for consumption. They may interfere with the normal digestion of the food and may be even toxic.

As far as milk is concerned, two types of preservatives are commonly used in the dairy industry.

- (1) Those to be added to samples meant for chemical analyses. Such milk is not meant for consumption. According to PFA rules, formalin (40% solution of formaldehyde) may be added @ 0.1 ml for each 25 ml milk to such samples which are to be preserved for chemical analysis. It is advisable to add some colouring matter to such preserved samples so as to prevent the danger of these being used by mistake for food purposes.

- (2) Second type of preservatives are those which are to market milk in order to enhance the keeping quality of stored or poor quality milk and sell it as fresh milk. It is unlawful and constitutes prosecution.

Qualities of a good preservative

An ideal preservative should have the following attributes :

- (i) It must not react with any of the food constituents.
- (ii) It must inhibit the growth or destroy the micro-organisms.
- (iii) It must be easily removable before food is made available for consumption.
- (iv) It should be non-toxic, colourless, odourless and tasteless.
- (v) It should be easy to add and should not be expensive.

None of the known preservatives meet all the qualities.

Adulteration:

Adulteration, in general, may be defined as the addition and/or subtraction of some of the legally prohibited substances into/or from a more valuable genuine product with the view to increase the bulk or quantity and to make more profit.

The chief objective of this malpractice is to increase the bulk or quantity or to lower down the quality of the product and yet to pass it off as genuine in order to increase the margin of profit.

The practice of adulteration has become very common in our country because of many reasons which include, for example, short supply of the food & increased demand, degraded moral society, desire for more profit, low purchasing power of the consumers etc.

Take the case of milk, adulteration of which was : considered a sin once upon a time has become the most vulnerable to this malpractice. The adulteration of milk is easier than any other food because of the physical nature of the milk. It can hide a number of things and easily take more of water because of its opaque and watery nature. The consistency after watering can easily be maintained by adding some thickening agents.

The chief adulterations of milk include the following:

- a) Removal of fat by skimming.
- b) Addition of separated milk or skim milk to whole milk.
- c) Addition of water (most common)

Addition of water to milk can be tested by determining freezing point of milk which is the most reliable and accurate test. Addition of water decreases the freezing point of milk.

d) Addition of thickening agents/soluble substances such as :

- i) Starch
- ii) Cane sugar
- iii) gelatin
- iv) Urea
- v) Ammonium sulphate etc.

Addition of these thickening agents increases the density of milk and thus prevents the detection of added

water by lactometers. However, all these substances can be detected by chemical tests.

c) Addition of <sup>o</sup>Colouring matter to watered buffalo milk.

Because the buffalo milk contains more total solids (consisting of fat and solids - not - fat constituents) therefore it can easily be adulterated with water and after the addition of some yellow colour can be sold as cow's milk. Generally the following colours are added

- i) Coal for dyes (Azo dyes)
- ii) Turmeric
- iii) Annatto colour
- iv) Carotene

Addition of these colouring matters can also be detected by chemical tests.

f) Addition of milk powder + water + foreign fats

Some-times skim milk or skim milk powder reconstituted with water is added with foreign fats (vanaspati etc.) and sold as whole milk after homogenizing.

g) Addition of pond water

It is a common practice in our country to adulterate the milk with the dirty water from any pond. The presence of such a dirty water in milk may be detected by the Nitrate test as all natural water contain nitrate while milk does not. The Nitrate test is based upon the principle that diphenylamino is oxidised by nitrates first to diphenylbenzidine and then to intense blue colour of quinone immonium salt.

Ghee is another example of food which is often sold in the adulterated form. Being the costliest among the other edible fats and oils, ghee offers itself an easy prey to admixture with cheap adulterants (animal or vegetable fats). The major portion of market ghee in India is adulterated. The situation is that one may get ghee consisting of 5 to 100% vegetable or animal fats, vanaspati (hydrogenated oils), starch, artificial flavouring agents etc.

The adulteration is freely practiced because of the complexity and wide variation in the chemical composition of ghee as milk fat is the most variable constituent not only in quantity but in quality too. It is composed of a large number of different fatty acids than any other type of fat found in nature. Further, these fatty acids also differ widely in their properties viz., solubility, volatility, molecular weight, degree of unsaturation etc. depending upon the number of conditions. This fact further ease the practice of adulteration.

#### Types of ghee adulteration:

Adulterants that have been used for the adulteration of ghee may be classified as follows :



W A T E R

Water is one of the most essential Constituents of the human environment. Man needs it for his physiological existence and for many other purposes such as industrial water supply, irrigation, propagation of fish and other aquatic life, generation of power etc. Water is odourless, colourless and tasteless liquid. As a chemical it is unique compound of great stability a remarkable solvent and a powerful source of chemical energy. When frozen into a solid it expands, instead of contracting as nearly all other substances do. It can absorb and release more heat than most common substances. The combination of two atoms of hydrogen and one of oxygen that comprises water ( $H_2O$ ) forms a sturdy molecule. Tremendous energy is needed to break water apart.

Water in its chemically pure form occurs rarely in nature. Infact, water is commonly found to carry a wide variety of constituents. The terms like 'pure', "clean" and "polluted" are often used in describing the quantity of water by a layman. Different standards and criteria have been prescribed for a specific use of water. For example, standards now exist for drinking water as well as a number of other purposes.

The changes in physical parameters of natural water are used as the direct and the indirect indices of the quality of water. However, the physical parameters are not absolute indices of water pollution and their normal values may vary considerably. When assessing the pollution of water, the deviations from the norm are generally used.

PHYSICAL PARAMETERS:-

Transparency - The transparency of water is determined by its colour and turbidity, i.e., by the content of various coloured and suspended organic and mineral substances.

Turbidity :- The turbidity of water is connected with the presence of suspended and colloidal substances of various origins. These substances contain particles of suspended silt including a complex mixture of solid organic and mineral substances, coagulating organic colloids of iron and aluminium hydroxide, microorganisms, phytoplankton and Zooplankton, etc.

COLOURATION:- The colour of the unpolluted water is caused chiefly by the presence of coloured humic substances and compounds of ferric iron (hydroxide, etc.) Polluted water may contain a vast variety of coloured organic, organo-mineral, and mineral compounds.

Temperature: The temperature of water is one of the most important characteristics which determines to a considerable extent, the changes in its quality. Temperature is an important factor affecting ion and phase equilibria and influencing the rates of biochemical processes which accompany the changes of concentration and content of organic and mineral substances.

Electric Conductivity:- Electric conductivity of natural water is determined by the presence of substances electrolytes which dissociate into cations and anions, The unit of electrical conductivity used is the specific electrical conductivity, which is the inverse of the electrical resistivity found between two electrodes each of which has an area of one square centimetre and are separated from one another by a distance of one centimeter. The units of the electrical conductivity is the reverse microhm. The correlation between the value of the specific electrical conductivity in general is quite a rough index of the total content of the dissolved substances.

pH:- The pH value of natural water is an important index of acidity or alkalinity and is the resulting value of the acidic/basic interaction of number of its mineral and organic components. Under natural conditions, the values of

pH in the surface water range usually from 5.0 to 8.6, but in some cases, the range is considerably greater.

Odour and taste :- Disagreeable odours and tastes in water are associated with the presence of any of a great variety of living microscopic organism or decaying vegetation. Problems of both odour and taste are very complex because the senses of smell and taste are intimately related and their responses are often difficult to differentiate clearly. However, certain non-volatile substances dissolved in water can cause tastes without forming odours.

CHEMICAL PARAMETERS:- Chemical parameters are the most important indices which characterise the quality of water. Their absolute values and correlations enable us to do the following:-

1. to classify the water by its mineralization, chemical composition (in particular, by the predominance of certain ions),
2. to evaluate the need to provide bodies of water with nourishing substances necessary for the development of aquatic organisms, such as compounds of nitrogen, phosphorus, silicon, iron trace elements.
3. to characterize the degree of water pollution and the nature of the prevalent pollutants, and
4. to record cases of sharp increase in the concentration of polluting substances and to pinpoint main source of pollution.

For a number of chemical parameters, certain limits (in water) have been established, the surpassing of which requires some necessary action. However, since the composition of water vary from region to region, it is impossible to establish strict norms in regard to their quality, only some basic criteria, however, can be recommended when the quality of water is studied. The maintenance of natural composition and the minimizing of harmful toxic substances must meet various requirements when water is used by various branches of industry, agriculture, fisheries etc. The systematic observations should include the determination of the following chemical parameters.

.....4/-

1. The major ions (bicarbonate, chloride, sulphate, calcium, magnesium, and sodium,
2. Dissolved oxygen,
3. Chemical oxygen demand,
4. Organic carbon,
5. Nitrogen compounds (Nitrites, nitrotes, and ammonia,
6. Phosphates
7. Silicic acids
8. iron; and
9. Biochemical oxygen demand (BOD)

The most widely pollutants prevalent are:

1. Phenols
2. Petroleum products
3. detergents
4. pesticides

In addition to the components mentioned above, the determination of the following is also important in evaluating the quality and suitability of water.

1. organic carbon
2. Inorganic and organic nitrogen
3. Inorganic and organic phosphorus and
4. trace elements (Aluminium, Arsenic, and heavy metals, among them most toxic such as mercury, lead, cadmium).

#### ACIDITY OF WATER

The acidity of pure water is mainly due to the free carbon dioxide dissolved in the water and is also produced by humic acids; fulvic acids, and other organic acids. If the acidity of the water is due only to these substances of natural origin its pH value is usually above 4.5. Water which has been polluted by industrial waste waters may contain considerable amounts of strong acid salts, which disrupts the carbonate equilibrium. The pH value of such water may be considerably below 4.5. Waters with pH less than 4.5 are known to contain

free or mineral acidity since natural water seldom have pH less than 4.5.

#### ALKALINITY OF WATER

The alkalinity of water is mainly due to the presence of bicarbonates, and carbonates of alkali earth metals. The pH value of such water generally does not exceed 8.3. Free and general alkalinity is determined by titrating the sample of water with standard acid to pH 8.3 and pH 4.5, respectively using phenolphthalein (pH 8.3) followed by methyl orange (pH 4.5) as indicators.

#### HARDNESS OF WATER

Water which does not easily produce a lather with soap is known as "hard" water. All natural <sup>waters</sup> contain small quantities of dissolved salts which vary greatly in composition from one area to another. Calcium and Magnesium are the principal alkaline earths in natural waters. Hardness of water presents many problems in the use of water. Some of these are.

i) Scale formation on heating surfaces in boilers and cooling water equipments.

ii) In cleaning processes, soaps, ~~before~~ forming a lather, react first with hard salts in waters to form insoluble calcium and magnesium stearates and oleates which form not only objectionable precipitates but also results in more consumption of detergents in producing lathering properties of water since no lather can be obtained with the soap until all the "hardness" has been reacted.

Hardness of water is of two types:-

1. Temporary Hardness, and
2. Permanent Hardness.

The temporary hardness of water is due to the presence of bicarbonates of calcium and magnesium and can be removed by



boiling the water. The bicarbonates of calcium and magnesium are converted into carbonates (as precipitates) and can be removed by filtration.



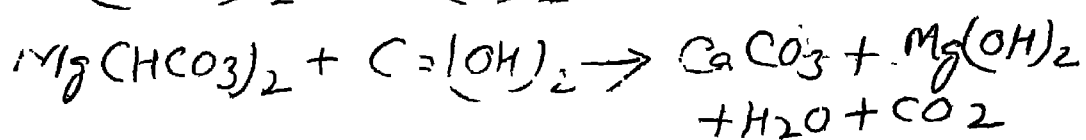
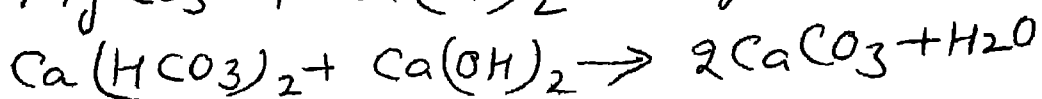
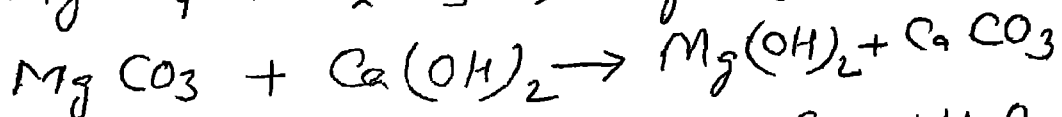
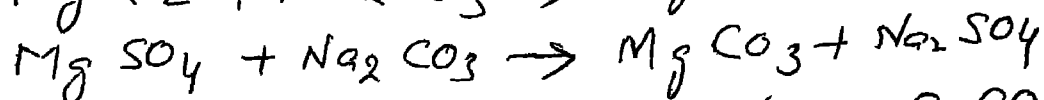
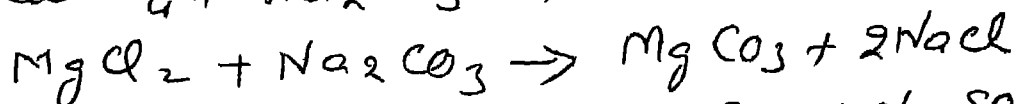
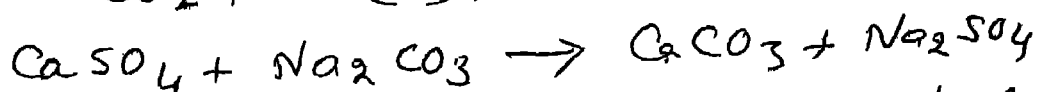
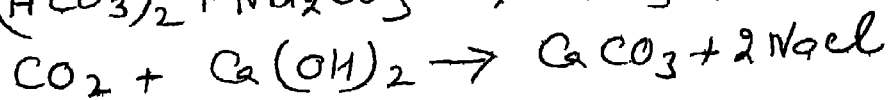
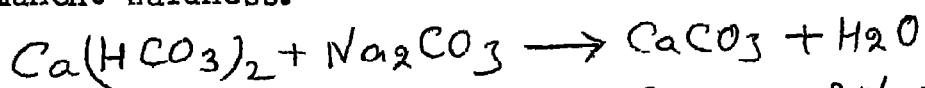
The permanent hardness (Non-Carbonate) of water is due to chlorides and sulphates of Calcium and magnesium and can not be removed by boiling. To remove permanent hardness, the water has to be chemically treated.

The quantity of calcium and of magnesium bound to carbonates and bicarbonates is called carbonate hardness and is expressed as ppm  $\text{CaCO}_3$ . Total hardness is the sum of both the carbonate and the non-carbonate hardness; the non-carbonate hardness is due to alkali earth sulphates and chlorides.

#### Common methods of water Softening

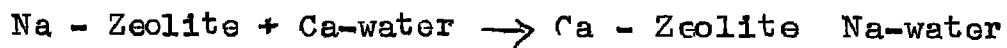
##### 1. Soda-lime process.

In this process, the calculated quantities of hydrated lime ( $\text{Ca (OH)}_2$ ) and Sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) are added in order to precipitate the compounds responsible for temporary and permanent hardness.

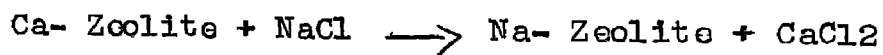


## 2. Zeolite or Base Exchange System

This process involves the percolation of water through a vessel containing Zeolite where upon a process of base exchange is brought about, calcium and magnesium leaving the water to enter the Zeolite and their place being taken by sodium.



By this method both types of hardness are removed, and the process is self-regulating. The Zeolite may be recharged by running a solution of salt through the apparatus.





SOLUTION

INTRODUCTION :

In a solution the molecules of one substance are uniformly distributed in to another substance. Solutions are homogeneous mixtures of two or more substances. The substances present in large concentration is referred to as solvent and the substance present in smaller concentration is called solute.

Solution may exist in the gaseous, liquid or solid states. The various types of binary solutions are given below:

<u>Solvent</u>	<u>Solute</u>	<u>Examples</u>
Liquid	Liquid	Alcohol in water
Liquid	Solid	NaCl with water
Gas	Gas	Air
Gas	Solid	Camphor in air
Solid	Gas	H <sub>2</sub> in Pd
Solid	Solid	Au in Cu (alloy)

Dilute and concentrated solutions:

A Dilute solution is one which contains small amount of solute in large amount of water.

A concentrated solution contains comparatively large amount of the solute in the solvent.

Saturated, Unsaturated and super-saturated solutions:

A solution which can't dissolve solute any longer at a given temperature is called a saturated solution.

An unsaturated solution contains a lower concentration of solute than a saturated solution.

A supersaturated solution is one which contains higher concentration of solute than a saturated solution.

Concentration units:-

Mass percent: the ratio of the mass of one component of a solution to the total number of moles of the solution.

1 If  $W_A$  - Mass in grams of solute

If  $W_B$  - Mass in grams of solvent

Then Mass per cent of solute (a) =

$$\frac{W_A}{W_A + W_B} \times 100 \%$$

Mass  
Volume

$W$  = Mass of the solute (say 5 g)

$V$  = Volume of the solvent

$$\frac{W}{V} \times 100\%$$

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Molarity (M) : It is defined as the number of moles of the solute present in one litre of the solution

$$M = \frac{\text{Number of moles of solute}}{V \text{ in litres}} \times 1 \text{ L}$$

$V$  is the volume of solution

1 Mole = Molecular Weight of a substance expressed in grams.

Now if a solution of lactose contains 34.2 g of lactose in

400 ml of water solution then molarity will be :

(1 Mole of lactose = 342 g)

$$\text{number of moles of lactose} = \frac{34.2}{342} = 0.10$$

0.10 mole of lactose is present in 400 ml or = 0.4 litre of the solution.

$$\text{Therefore, } M = \frac{0.10}{0.4} \times 1000 = 0.25$$

Normality (N) : It is defined as the number of grams equivalent of the solute present in one litre of the solution.

$$N = \frac{\text{number of gram equivalent of solute}}{\text{litres}} \times 1 \text{ L}$$

Thus a normal solution contains one gram of equivalent for

litre of the solute. So 0.1N or  $\frac{1}{10}$  solution is meant a

solution which contains one tenth gram equivalent of the solute per litre.

-52:-

It normality can also expressed as:

$$\text{Normality} = \frac{\text{Strength of g/l}}{\text{equivalent weight}}$$

~~(p. 1-42) ...~~

~~Colligative properties of solutions:~~

~~1. ... of ... of a liquid~~

~~... at which the ... of the~~

$$\therefore \text{Eq. wt. of } \text{FeSO}_4 = \frac{\text{M.Wt. of } \text{FeSO}_4}{1} = 152.$$

### Equivalent Weight

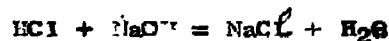
The equivalent weight of a substance is that much weight of it which is chemically equivalent to one gram atom of hydrogen,  $\frac{1}{2}$  gram atom of oxygen or 1 gram atom of chlorine. The relation between molecular and equivalent weight of a substance is:

$$\text{Equivalent Weight} = \frac{\text{Mol. Wt.}}{n}$$

n representing the number of gram atoms of H or  $\frac{1}{2}$  O.

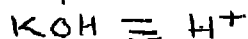
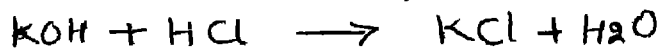
atoms of O, equivalent to one gram molecule of the substance.

1. For an acid, n equals the number of H atoms in one molecule of the acid. Thus:



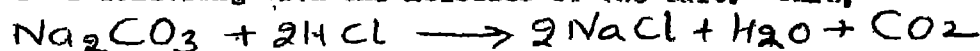
$$\therefore \text{Eq. wt. of HCl} = \frac{\text{M.Wt. of HCl}}{1} = \frac{36.5}{1}$$

2. For a base, n equals the number of H<sup>+</sup> ions that react with one molecule of the base. Thus,



$$\therefore \text{Eq. wt. of KOH} = \frac{\text{M.Wt. of KOH}}{1} = \frac{39 + 16 + 1}{1} = 56$$

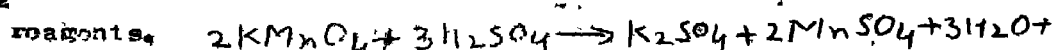
3. For an acidic or basic salt, n equals the number of H<sup>+</sup> or OH<sup>-</sup> ions reacting with one molecule of the salt. Thus,



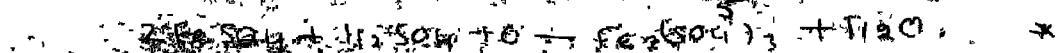
$$\therefore \text{Eq. wt. of Na}_2\text{CO}_3 = \frac{\text{M.Wt. of Na}_2\text{CO}_3}{2} = \frac{2 \times 23 + 1 \times 12 + 3 \times 16}{2} = 53$$

4. For an Oxidising or Reducing Agent, n equals the number of

$\frac{1}{2}$  O atoms furnished by or reacting with one molecule of the



$$\therefore \text{Eq. wt. of KMnO}_4 = \frac{\text{M.Wt. of KMnO}_4}{5} = 31.6$$



## Colligative properties of solutions

Elevation of boiling point:- The boiling point of a liquid is the temperature at which the vapour pressure of the solvent reduces on addition of a non-volatile solute. Thus to make vapour pressure equal to the atmospheric pressure, it is necessary to heat the solution to a higher temperature. This means that the boiling point of the solution is higher than the pure solvent.

Depression in freezing point: The freezing point of a liquid

is the temperature at which the vapour pressure of the liquid and the solid states of the substance are the same. It has been found that the freezing point of solution lowers down on addition of a non-volatile solute in the solvent.

## A Colloidal State

Some substance diffuse rapidly in a solvent and make solution and readily pass through animal or vegetable membranes, and some others do not respond readily. Urea, sugar, salts, acids, bases, etc. diffuse readily in solution and are called crystalloids. Gels, starch, albumen, glue, etc. do not diffuse readily in solution and are called colloids.

Colloidal state is a heterogeneous system intermediate between a suspension and a true solution. In a colloidal solution, solute particles remain dispersed in a dispersion medium (solvent) and are quite small in size ( $10^{-5}$  to  $10^{-7}$  cms); size is midway between size of the solute in solution ( $10^{-7}$  cm) and suspension ( $10^{-5}$  cm). Particles keep floating. Each particle is confined to its boundary surface which separate it from the continuous dispersion medium.

Property	Solution	Colloid	Suspension
1. Size of particles	$10^{-7}$ cm	$10^{-5}$ to $10^{-7}$ cm	$10^{-6}$ cm
2. Type of mixture	Homogeneous	Heterogeneous but appears to be homogeneous	Heterogeneous
3. Appearance	Transparent	Translucent	Opaque
4. Visibility of particles	cannot be seen even under powerful microscope.	Can be seen by a powerful microscope	Visible to naked eye
5. Separation by filtration	Not possible	cannot be separated by ordinary filtration	can be separated by ordinary filtration

Colloid particles are characterized by an especially high ratio of surface area to mass, so that even a small amount of colloid may have a large working surface. This provides increased opportunities for chemical action, for different chemicals to meet and interact.

Emulsion: A liquid dispersed in a liquid dispersing medium is known as an emulsion. Milk the most common example of an emulsion is simply fine particles of fat suspended in an aqueous medium. It also contains casein which stabilizes the emulsion. Here casein works as an emulsifier and is called emulsifying agent. This emulsion belongs to oil in water type emulsions. Water in oil is another type of emulsion. Butter is an example of this class—where fine particles of water are disseminated in medium of fat.

#### Surface tension:

In a liquid, the molecules are much closer together and the cohesive forces are much stronger. A molecule in the body of a liquid is completely surrounded on all sides by other molecules and inter-molecular attractive forces are, on the average, exerted equally in all directions.

A molecule at the surface of a liquid, however, is surrounded on one side by molecules in the liquid and, on the other, by more widely

scattered molecules in the vapour state. Such surface molecules will, therefore, experience inward attractive forces which account for the surface tension of liquids. This causes liquids to behave as though their surfaces consist of an elastic skin and one indication of this is

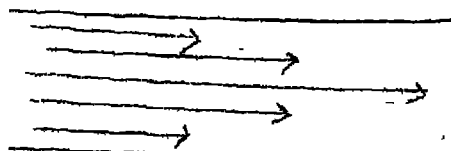
that liquid surfaces usually assume the smallest possible area. This means that freely suspended liquids form into spherical drops. The state of tension at a liquid surface, which is really one of forces acting inwardly is called surface tension.

Since the forces of attraction between the molecules of a liquid decrease with <sup>increase</sup> temperature, it follows, therefore that the surface tension will decrease when the temperature is increased.

### Viscosity

Liquids flow at different speeds. For example, water flows with greater speed than honey. Obviously, some sort of internal friction is operating which hampers the flow of liquids and which varies from liquid to liquid. This internal friction is primarily due to forces of attraction between the molecules. If we consider a flow of a liquid in a tube then the velocity of the layer touching the wall of the tube is zero and it increases as we proceed towards the centre of the tube. Due to greater intermolecular attractions, the molecules moving in any one layer will tend to hamper the movement of the molecules in the adjoining faster moving layer. As a consequence the velocity of molecules in the faster moving layer increases. Thus, viscosity is the resistance to the flow of a fluid substance.

The viscosity of a liquid decreases with increase of temperature since the effect of intermolecular attractions is decreased.



Arrangement of molecules within and at the surface of liquid in a tube

## ACIDS AND BASES

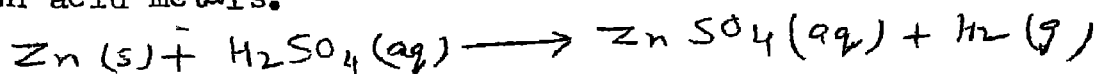
### Acids

The word 'acid' is commonly used in every day life.

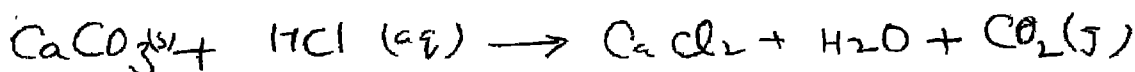
Solution of acids have a sour taste. Sour taste of spoiled milk is due to lactic acid.

Solutions of acids turn blue litmus red. Litmus is dye obtained from lichens and its solution is often used in the laboratory to determine whether a solution is acidic or not.

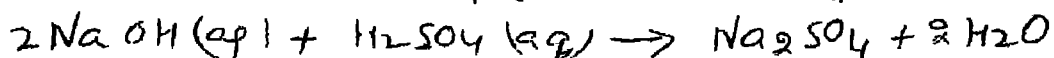
Solutions of acids usually yield hydrogen on reacting with acid metals.



Solutions of acids liberate  $\text{CO}_2$  from carbonates.

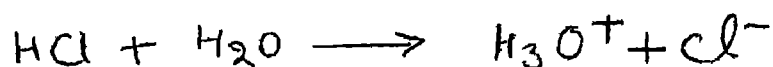


Acids react with oxides or hydroxides of metals to yield salt



Thus an acid is often defined, on the basis of above properties, as a substance which turns blue litmus red and contains hydrogen, all or most of which can be replaced by a metal, directly or indirectly, with the formation of salt.

This definition is also true for some substance which are not acids. It is the hydrogen ions obtained from all acids when they are dissolved in water which account for their general similarity in chemical properties. Thus the proper definition of an acid is: A substance which on dissolving in water yields hydrogen ions.

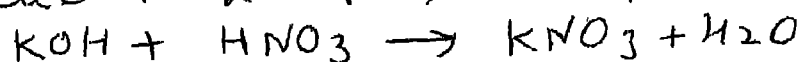


### Bases

Solution of bases have bitter taste and they feel slippery to the touch.

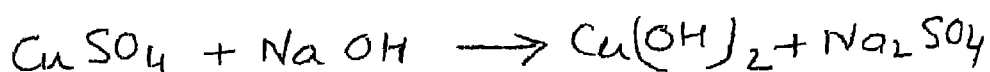
Solution of bases turn red litmus. blue.

Solution of bases react with acids to form salts.



Very few bases dissolve in water, those that do are called alkalies.

Solutions of alkalies precipitate insoluble metallic hydroxides on interacting with solutions of salts of many metals.



Thus, it is clear that the hydroxide ions produced by alkalies/bases are responsible for their general similarity of behaviour in the reactions listed above.

Therefore, a base is a substance that furnishes hydroxyl ions, when dissolved in water.

#### Basicity of acids :

Basicity of an acid is the number of hydrogen ions which can be given by one molecule of that acid.

or

Basicity of an acid is the number of hydrogen atoms in one molecule of that acid, which can be replaced by a metal.

#### Acidity of bases:

Acidity of a base is the number of hydroxyl ions which can be given by one molecule of that base.

#### The strength of acids and bases :

The strength of different acids and bases may be compared by using a mixture of different dyes known as 'Universal indicators.' The colour of this mixture depends upon the concentration of  $\text{H}^+$  ions/which determine acidity) in a solution.



It has been found convenient to express acidity by using a scale of numbers known as the pH scale. Water has a pH of 7 and is described as neutral. Solutions which have pH greater than 7 are called basic; solutions with pH lower than 7 are called acidic. The lower the pH value the more acidic is a solution.

colours of universal indicator							
pH	4	5	6	7	8	9	10
colour	Red	orange	Yellow	Green	Blue	indigo	violet
Acidity/basicity	most acidic.....Neutral.. Most basic						

### The pH scale

In 1909, Peter sorenson defined the pH as the negative power to which 10 must be raised equal to the hydrogen ion concentration i.e.

$$H^+ = 10^{-pH}$$

The pH can be expressed directly in the following equation :

$$pH = -\log (H^+)$$

In the same fashion, we can define the pH as the negative logarithm of the hydroxide concentration, as follows:

$$p(OH) = -\log (OH^-)$$

Suppose the hydrogen ion concentration in a given solution is  $10^{-4}$  M. Then the pH will be  $pH = -\log (10^{-4})$   
 $pH = -(-4) \log 10$   
 $pH = 4$

Similarly in pOH of a solution with  $10^{-6}$  M hydroxide ion concentration will be 6. The pH and pOH of any solution are related to one another by the following equation:

$$pH + pOH = 14.$$

The pure water is neither acidic nor basic, since  $[OH^-], [H^+] = 10^{-7} M$  i.e. the pH of pure water is 7. In acid solutions, the concentration of the hydrogen ion is always greater than  $10^{-7} M$  and the pH is always less than 7. In basic solutions, the hydrogen ion concentration is always less than  $10^{-7} M$  and the pH is greater than 7.

## Indicators

Indicators: An indicator is a reagent which makes the end point of a chemical reaction visible by undergoing the colour change.

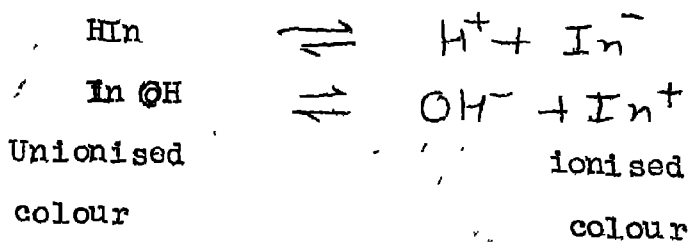
A number of complex organic molecules have the property of changing their molecular structure and colour when placed in solutions in which there is a change of acidity or alkalinity i.e. pH. Because of this they are of value in "indicating" the neutralization or equivalence points when two chemicals are present in exactly the correct proportions necessary to react with each other. The indicators find their application in the volumetric titrations in which the concentration of one reagent can be found if the concentration of the other reagent is already known.

### How the Indicator works ?

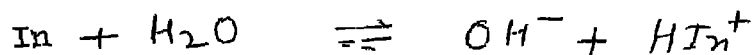
When the solution B is gradually added to the solution A containing an indicator, it first reacts with A completely and then becomes in slight excess. The indicator at this point either changes colour or forms a coloured precipitate with excess of B and thus shows the end-point clearly.

### Theory of Indicator action

The first useful theory of indicator was suggested by W. Ostwald (1891). He considered that the undissociated indicator acid (HIn) or base (InOH) had a different colour from that of its ion. The equilibria in aqueous solution may be written :

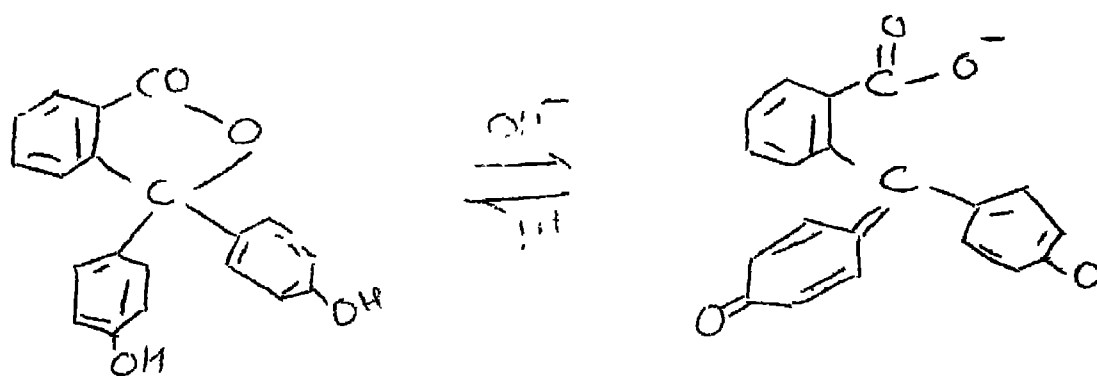


If the indicator is an anhydro base (In), for example, a free amine or substituted amine, the equilibrium is :



### Chemistry of Indicators

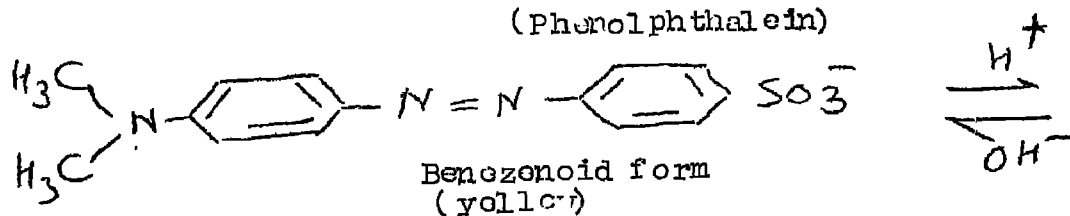
Indicators, in general are either organic weak acids or weak bases with a characteristic of having different colours in the ionized and unionized forms. For example, phenolphthalein is a weak acid (ionized form is pink and unionized form is colourless) and methyl orange is a weak base (ionized form is red and unionized form is yellow). These forms for phenolphthalein and methyl orange indicators are shown below:



Benzenoid form  
(colourless)

Quinonoid form  
(pink)

(Phenolphthalein)



Benzenoid form  
(yellow)

Quinonoid form  
(red)

(Methyl orange)



(Acid-Base Indicators)

### Types of indicators

These are of two types

#### (1) Acid-base indicators

They are used for acid-alkali titrations. Most commonly used are phenolphthalein and Methyl orange indicators.

#### (ii) Indicator for other purposes

These are used for chemical reactions other than the acid - alkali titrations. For example oxidation - reduction reactions, and those involving complex formation between metal ions with organic reagents. Examples are potassium chromate indicator, starch indicator, ferric alum etc.

### Selection of the Indicator

The choice of the Indicator for a particular titration depends upon the nature of the acid and the alkali to be titrated. The selection of indicator for acid-base titrations is shown in the table.

<u>Acid</u>	<u>Alkali</u>	<u>Indicator</u>
Strong	Strong	Phenolphthalein or methyl orange.
weak	strong	Phenolphthalein Methyl orange
Strong	weak	Methyl orange

Strong acids are  $HCl$ ,  $H_2SO_4$ ,  $HNO_3$

Weak acids are acetic acid, oxalic acid, citric acid (All organic acids).

Strong alkalies are  $NaOH$  and  $KOH$

Weak alkalies are  $Na_2CO_3$ ,  $K_2CO_3$ ,  $NaHCO_3$ ,  $KHCO_3$  (All carbonates & bicarbonates).

Note - For titrating a strong acid against a strong alkali although both the indicators can be used, but phenolphthalein should be preferred to methyl orange.

It gives a clear indication of the end point.

Different indicators change colour over different ranges of pH, and the most useful are those having a distinct colour change over a narrow range of pH. Some of the common indicators along with their colour change in acid & base, and pH range are given below in the Table -

Colour change and pH range of some of the acid-base indicators

Indicator	Chemical Name	Colour in acid solution	Colour in alkaline solution	pH range
Cresol red (acid)	O-Cresol-sulphone phthalein	Red	Yellow	0.2 - 1.8
Thymol blue	Thymol-sulphone phthalein	Red	Yellow	1.2 - 2.8
Bromo-phenol blue	Tetrabromophenol sulphone phthalein	Yellow	Blue	2.8 - 4.6
Methyl orange	Dimethyl amino-azo benzene - sodium sulphonate	Red	Yellow	3.1 - 4.4
Bromocresol green	Tetra bromo-m-cresol-sulphone - phthalein	Yellow	Blue	3.8 - 5.4
Methyl red	o-Carboxy-benzene - azo - dimethylaniline	Red	Yellow	4.2 - 6.3
Bromo-cresol purple	Dibromo-o-cresol - sulphone phthalein	Yellow	purple	5.2 - 6.8
Bromothymol blue	Dibromo-thymol - sulphone - phthalein	Yellow	Blue	6.0 - 7.6
Phenol red	Phenol-sulphone-phthalein	Yellow	red	6.8 - 8.4
Cresol red (base)	O-Cresol - sulphone phthalein	Yellow	red	7.2 - 8.8
Thymol Blue (base)	Thymol-sulphone - phthalein	Yellow	Blue	8.0 - 9.6
Phenol-phthalein	Phenol-phthalein	Colourless	Pink-red	8.3 - 10.0
Turmeric	-	Yellow	Orange	8.0 - 10.0
Alizarine - Yellow R	p - nitro-benzene - azo - salicylic acid	Yellow	Red-orange	10.0 - 12.0

Preparation of working solution for some of the commonly used indicators

1) Cresol red (acid) indicator

Dissolve 0.1 gm in 13.3 ml of 0.02 M NaOH and make up to 250 ml with distilled water.

2) Thymol blue (acid) indicator

Dissolve 0.1 gm in 10.75 ml of 0.02 M NaOH and make up to 250 ml with distilled water.

3) Bromophenol blue indicator

Dissolve 0.1 gm in 7.5 ml of 0.02 NaOH and make up to 250 ml in distilled water.

4) Methyl orange indicator

Dissolve 0.1 gm in distilled water and make up to 100 ml.

5) Bromocresol green indicator

Dissolve 0.1 gm in 7.25 ml of 0.02 M NaOH and make up to 250 ml with distilled water.

6) Methyl red indicator

Dissolve 0.1 gm in 18.6 ml of 0.02 M NaOH and make up to 250 ml in distilled water.

7) Bromocresol purple indicator

Dissolve 0.1 gm in 9.25 ml of 0.02 M NaOH and make up to 250 ml with distilled water.

8) Bromothymol blue indicator

Dissolve 0.1 gm in 8 ml of 0.02 M NaOH and make up to 250 ml with distilled water.

9) Phenol red indicator

Dissolve 0.1 gm in 14.3 ml of 0.02 M NaOH and make up to 250 ml with distilled water.

10) Cresol red (base) indicator

Dissolve 0.1 gm in 13.3 ml of 0.02 M NaOH and make up to

11) Thymol blue (base) indicator

Dissolve 0.1 gm in 10.75 ml of 0.02 M NaOH and make upto 250 ml with distilled water.

12) Phenolphthalein indicator

Dissolve 0.1 gm in 50% aqueous ethanol and make upto 100 ml with 50% aqueous ethanol.

13) Thymolphthalein indicator

Dissolve 0.1 gm in 80% aqueous ethanol and make upto 100 ml with 80% aqueous ethanol.

14) Alizarine yellow R. indicator

Dissolve 0.1 gm in distilled water and make upto 100 ml.

15) Litmus: solution (Blue)

Dissolve one gm of the solid in 100 ml of water.

16) Litmus: solution (Red)

To the blue litmus: solution prepared above add a drop or two of dil. HCl in order to change its colour to red.

17) Ferric ammonium sulphate indicator (10% w/v)

Dissolve 10 gm in distilled water and make up the volume to 100 ml.

18) Acid ferric ammonium sulphate indicator

Dissolve 0.2 gm of ferric ammonium sulphate in 50 ml of distilled water, add 6 ml of dilute nitric acid (concentrated acid diluted 1+9 with dist. water) and make up the volume to 100 ml with distilled water.

19) Potassium chromate (5% w/v) indicator

Dissolve 5 gm in distilled water and make up the volume to 100 ml.



20) Starch indicator solution

Mix the minimum volume of water with 1 gm of starch (preferably soluble starch) and 5 mg of mercuric iodide to form a smooth paste. Then stir in 500 ml boiling distilled water and boil the mixture for further 1 - 2 min. If the solution is not clear, allow it to stand to separate. Decant off the clear supernatant liquid into the indicator bottle.

21) Mixed indicator solution for nitrogen estimation

Mix equal volumes of a saturated solution of methyl red in ethanol (95% by volume) and a 0.1 percent solution of methylene blue in ethanol (95% by volume).

22. Methylene blue indicator for lactose estimation

Dissolve 1 gm in distilled water and make up the volume to 100 ml.

23. Saturated ferric alum indicator solution for chloride estimation

Boil excess of iron alum in 10% nitric acid, cool and filter.

Universal or multiple range indicators

By suitably mixing certain indicators the colour change may be made to extend over a considerable portion of the pH range. Such mixtures are usually called "Universal or Multiple range indicators". Such multiple range indicator solution can be used to find out the approximate pH of the solutions.

Multiple range indicator solution (for example, the BDH "universal" indicator) and Multiple range indicator test papers are also commercially available. A "wide range" or universal test papers covering pH 1-2 to 10, as well as a number of "narrow range" indicator test papers which cover most of the pH range in steps of 1.5 - 2 pH units are available in the market.

## Neutralizers

Only the experimental method of inspection - chemical analysis have been set for all types of foods under the purview of food adulteration laws (F.F.A. rules). Any sample of milk, cheese or any other food sold in the market, if it does not satisfy the minimum standard specified for the adulteration, has to be treated as adulterated.

It should be borne in mind that incorporation of chemical additives to some of the foods is mandated by the law. The purpose of such additives is to preserve the quality of the food by preventing its spoilage or improving its nutritive value. The use of such additives is also treated as adulteration.

### Neutralizers:

Neutralizers are chemical substances which are alkaline in nature. They are added to the food in order to regulate the hydrogen ion concentration i.e. acidity of the product. The neutralizers generally used are alkalies such as :

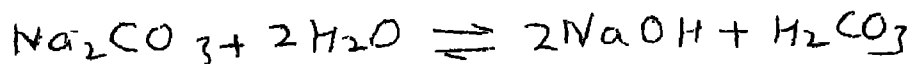
- (i) Carbonates and Bicarbonates ( $\text{Na}_2\text{CO}_3$  &  $\text{NaHCO}_3$ )
- (ii) Hydrated lime ( $\text{Ca}(\text{OH})_2$ )
- (iii) Caustic soda ( $\text{NaOH}$ )

Among these alkalies, sodium hydroxide is a very strong alkali and it has to be used with great care due to the danger of over neutralization.

- (1) Sodium Carbonate ( $\text{Na}_2\text{CO}_3$ )

Sodium carbonate is also known as washing soda or Soda Ash or Calcined Soda. It is a compound of sodium. The usual commercial form is an anhydrous powder ( $\text{Na}_2\text{CO}_3$ ), but soda monohydrate ( $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ ) and the decahydrate ( $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ) are also sold.

Sodium carbonate is moderately soluble in cold water and very soluble in hot water. The aqueous solution is strongly alkaline, due to hydrolysis, and this is the basis for some of its uses.



Soda ash is sold in bags, barrels or bulk to contain the equivalent of 58% of sodium oxide,  $\text{Na}_2\text{O}$  which, corresponds to 99% of soda ash.

Soda ash is to be considered among the less expensive alkalies when used to neutralize acid. The neutralizing value of 1 pound of soda ash equals that of about three-fourths pound of caustic soda, which sells for more than twice as much. Soda ash is fused with lime and sand to produce glass. Large amounts of sodium carbonate are used in industries like textile, paper, petroleum refining, paints etc. It is also used for softening of hard water. Sodium carbonate is commonly used as titrant for standardising acids volumetrically.

(ii) Sodium Bicarbonate ( $\text{NaHCO}_3$ )

Sodium bicarbonate is also known as sodium acid carbonate or Baking Soda. It is moderately soluble in cold water and much more soluble in hot water. The aqueous solution is mildly alkaline even though structurally it is an acid salt of carbonic acid. It is produced as an intermediate product in the solvay process for manufacture of soda ash and sold in granular and powdered forms. The latter contains not less than 99% of sodium bicarbonate. It tends to give off carbon dioxide to form a minor amount of sodium carbonate on exposure to air. Sodium bicarbonate is used as an ingredient of baking powder and effervescent ~~medicines~~ ~~drugs~~ ~~or acids~~ it liberates

the necessary gas, carbon dioxide. For those used it is more suitable than soda ash because the bicarbonate requires only half as much acid to decompose it. The mild alkalinity finds many other applications, for example, sodium bicarbonate is also used in digestive powders to correct the excessive acidity of the stomach.

(iii) Calcium Hydroxide ( $\text{Ca}(\text{OH})_2$ )

Calcium hydroxide is also known as calcium hydrate, slaked lime or hydrated lime. It is a dry, white powder whose solution, called lime water, gives a weakly alkaline reaction.

Calcium hydroxide is only slightly soluble in water, 0.17% in cold water and only about half that in hot water. The white suspension of the powder in water is known as Milk of Lime, or Lime Slurry. When reacting chemically, the soluble part reacts first; as this is used up more suspended solid dissolves and this in turn reacts. The action is therefore a progressive one. The final effect may be the same as with a stronger alkali, but the calcium hydroxide requires more time to react.

Calcium hydroxide is prepared by the action of water or steam on the anhydride, calcium oxide,  $\text{CaO}$ , known as Lime or Quicklime.

Slaked lime is used in the manufacture of more expensive alkalis from naturally occurring salts, such as in the lime-soda process for caustic soda. It is used in large amounts to neutralize acids in the chemical industry.

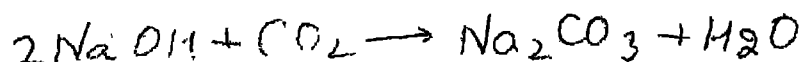
Calcium hydroxide is also used in the manufacture of bleaching powder, purification of sugar juices, water softener, in white wash, in water paints, in agriculture, and as an anti-acid in medicine. Lime soaps are prepared from calcium hydroxide and used in lubricants and greases. Good quality lime is the basic material for the manufacture of many calcium salts. Where applicable, lime is outstanding as the inexpensive industrial alkali.

(iv) Sodium Hydroxide (NaOH)

Sodium hydroxide is also known as caustic soda or sodium hydrate. It is a white translucent solid. Its aqueous solution is strongly alkaline. The solubility in water is so great that a solution can be prepared containing over 70% of the alkali. It is also soluble in alcohol, ether and glycerine. In some industries the aqueous solution is called Lye or Soda Lye. The household product sold under the name of lye is caustic soda.

Caustic soda is manufactured from other sodium compounds. One method starts with sodium carbonate,  $\text{Na}_2\text{CO}_3$ , Soda ash. This is treated in solution with slaked lime. The two react to form caustic soda solution and calcium carbonate. The latter is insoluble and precipitates. The supernatant liquid containing NaOH is drawn off and evaporated.

Analytical grades of sodium hydroxide appear most commonly as sticks crystallized from alcohol, and as pellets and flakes. Caustic soda takes up both water and carbon dioxide from the air; therefore it must be kept in closed containers or it will deteriorate rapidly. Protection from air is important, as some sodium carbonate is practically always formed, as follows,



Commercial forms of sodium hydroxide are as powder, flake, lump or liquid.

Caustic soda is commonly used in the manufacture of soap. Ordinary or hard soap consists of the sodium salt of fatty acids. It is also used extensively in oil refining, and as a reagent in many other industries. It is the strong alkali generally used in industry when a water-soluble alkali is essential.

Sodium hydroxide being a strong alkali it freely forms salts with acids e.g.

#### Neutralizers in dairy industry.

Milk is highly perishable, and during storage, it undergoes microbial action and develops acidity mainly due to the partial conversion of milk sugar (Lactose) to lactic acid. The conversion of lactose to lactic acid is shown as follows :



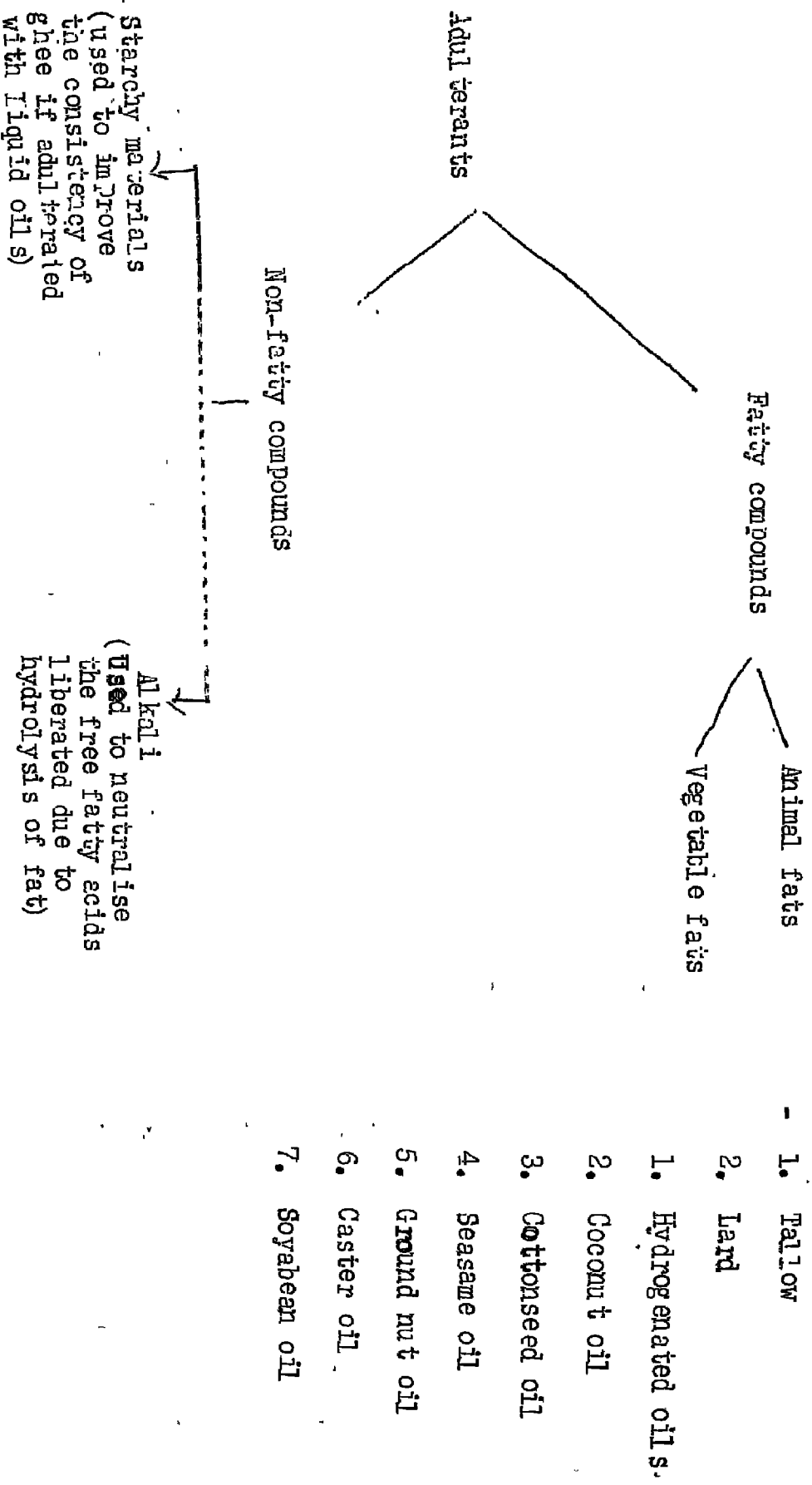
During summer, when the temperature is very high, milk received at the processing plant may be too acidic to allow satisfactory heat processing. As such it may not be accepted by the milk plant as it may curdle during processing because of high acidity. If such a highly acidic milk is used for the manufacture of milk products it will result to final product of inferior quality.

Because of the poor keeping quality of milk particularly under the tropical conditions and poor transport and chilling facilities, the producers or the middlemen attempt to neutralise the developed acidity of milk by the addition of various neutralizers such as sodium hydroxide, carbonates, bicarbonates, hydrated lime etc. so as to prevent the rejection of poor quality milk. Such a practice of adding neutralizers to milk is not permitted under the prevention of Food Adulteration (PFA) rules, 1955. Therefore the quality of milk has to be tested by chemical analysis before the milk is accepted at the milk collection centres and Central Dairy.

Legally the compositional limits and physico-chemical properties have been set for all types of foods under the prevention of food Adulteration Rules (PFA rules). Any sample of milk, ghee or any other food sold in the markets if it does not satisfy the minimum limits prescribed for the composition, has to be treated as adulterated.

However, it should be borne in mind that incorporation of certain additives to some of the foods is permitted by food laws upto a prescribed limit for some specific objectives of either preserving the food or improving the physico-chemical quality of the product. Addition of these additions beyond the permitted levels is also treated as adulteration.

Types of ghee adulteration





### Detergents

Detergents are mixtures of inorganic and organic compounds made for the purpose of cleaning objects and surfaces. Cleaning implies a process of removing dirt and dust from the material being cleaned. To do this they should possess the following properties.

1. Wetting and penetrating power i.e. ability to bring the cleaning solution into intimate contact with the surface to be cleaned.
2. Emulsifying power i.e. ability to emulsify greases and remove dirt and dust.
3. Saponification power i.e. ability to saponify fats and oils so that they can be removed from the surface to be cleaned.
4. Deflocculating power and chelating i.e. the ability to keep the insoluble salts into solution.
5. Free Rinsability i.e. ability to be removed easily and quickly.
6. Water softener power i.e. ability to remove the hardness of water.
7. Easy and complete solubility
8. Non-corrosive on cleaning surfaces of various materials.
9. Non - toxic
10. Non - caking and non-dusting in nature.
11. Low Cost.
12. Should not be harmful to skin when to be used for hand cleaning.
13. Germicidal properties i.e. ability to sanitize the surface to be cleaned.
14. Long keeping quality i.e. should not decompose during storage.

Since no single substance possess all the desirable

## TYPES OF DETERGENTS

### Types

Detergents are generally grouped into four classes of compounds. There are:

1. Alkalies
2. Phosphates and chelating compounds
3. Wetting agents
4. Acids

### 1. ALKALIES :

The important compounds in this category are :-

1. Caustic soda ( $\text{NaOH}$ )
2. Soda ash ( $\text{Na}_2\text{CO}_3$ )
3. Meta Sodium Silicates ( $\text{Na}_2\text{SiO}_3$ )
4. Meta sodium phosphates ( $\text{Na}_3\text{PO}_3$ )

The major functions of this group are dirt and dust displacement by emulsifying, saponifying and peptizing.

### 2. PHOSPHATES AND CHELATING COMPOUNDS

1. Sodium pyrophosphate ( $\text{Na}_4\text{P}_2\text{O}_7$ )
2. Sodium tripolyphosphate ( $\text{Na}_5\text{P}_3\text{O}_{10}$ )
3. Sodium tetrakisphosphate ( $\text{Na}_6\text{P}_4\text{O}_{13}$ )
4. Sodium hexametaphosphate ( $\text{Na}_6\text{P}_6\text{O}_{18}$ )

These pyrophosphates are considered, mainly for their water softening capabilities, although they possess emulsification, dispersion and rinsing ability to some extent.

Sodium salts of ethylene diamine tetra acetic acid and salts of certain other organic acids are used for treating calcium and magnesium hardness due to their sequestering action.

### 3. WETTING AGENTS

Wetting agents are three types :-

1. ANIONIC (alkyl and aryl sulfonates) Examples are :

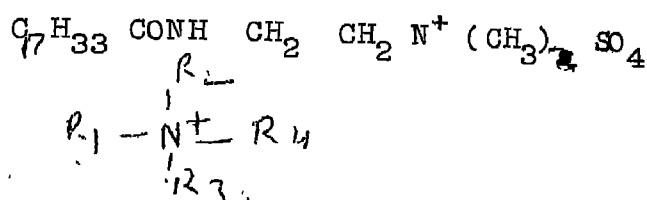
(a) Sodium dodecyl benzene sulfonate



by sodium dodecyl sulphate ( $C_{12}H_{25}OSO_3Na$ ). They ionize in the solution (as soap does) with the long hydrocarbon chain carrying a negative charge.

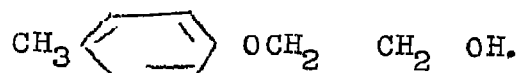
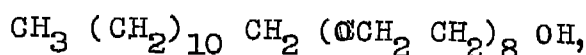
2. CATIONIC : Quaternary ammonium compounds).

for example :



3. NON-IONIC : (Alkyl aryl ethylene oxide derivatives)

Examples are :-



They do not ionize in solution.

These wetting agents used in minute quantities improve the wetting and rinsing abilities by forming stable emulsions and dispersions.

ACIDS :

Both inorganic and organic acids are used as dilute solution (1%) and they are effective at PH 2.5 or lower.

Inorganic acids : Nitric acid, phosphoric acid.

Organic acids : Acetic acid, Hydroxyacetic acid tartaric acid.

FORMULATION OF DETERGENT MIXES :

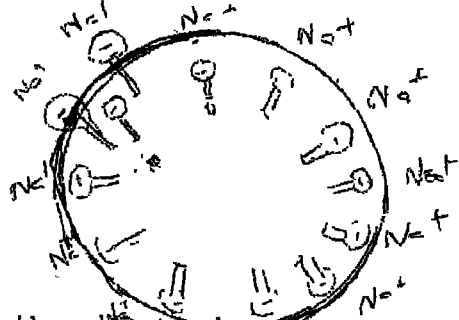
Generally detergent formulations are of two types :

1. Alkaline, and
2. Acidic.

The basic requirements of alkalinity and acidity are supplied by a major compound of alkaline or acid type. The formulation is further improved by the addition of phosphates/chelating agents to treat calcium and magnesium hardness and the addition of wetting agents to improve rinsability.

### HOW DETERGENTS WORK ?

Detergents lower the surface tension of water and cause the water to wet the surfaces of substances that normally have little attraction for water. To understand this process of cleansing let us consider the case of soap as a detergent. The soap molecule is a paraffin-chain salt ( $C_{17}H_{35}COONa$ ) which consists of two parts: a long hydrocarbon chain ending in a carboxylate anion ( $C_{17}H_{35}COO^-$ ) and a salt type group ( $Na^+$ ) attached to the end of the chain. The long hydrocarbon chain is insoluble in water but soluble in oils. The former is said to be 'hydrophobic' or water-hating and the latter is said to be "hydrophilic" or water-loving. The hydrophilic salt group (head) tends to pull the whole molecule into solution, whereas the hydrophobic group (tail) resists this tendency. As a result of these conflicting tendencies, the hydrophilic group is anchored in the water and the hydrophobic group stands as far away from water as possible projecting upwards in the air. The hydrophobic anions do not concentrate at the surface, but can escape from the water in a different way, e.g. by grouping themselves into spherical colloidal particles. Which are known as "micelles". The micelles are formed in such a way that the hydrophobic tails are in the centres of the spheres as they try to avoid the water (fig.).



(Fig. from the text by Puran Chandra (1976) School Science  
Vol. XIV No. 3 page 31).

The surfaces of the micelles are formed by the hydrophilic heads. These micelles act as reservoirs of detergent molecules ready to come into action as required to remove dirt.

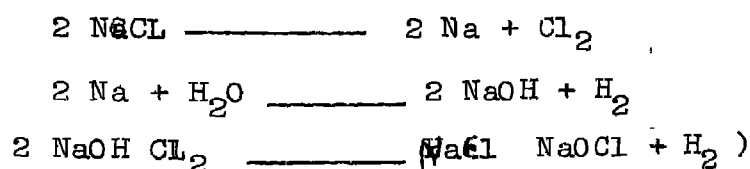
## CHEMICAL SANITIZERS

### SANITIZATION :

It is the process of reducing microbial load of the surface to be sanitized to a level considered safe from public health point of view in terms of destruction of pathogens and other micro-organisms. Effective sanitization is possible only if the surface is thoroughly cleaned. The various methods employed for sanitization are: i) application of heat, ii) ultraviolet radiations and iii) chemical compounds. There are occasion when application of heat and ultraviolet radiations cannot be used since these involves infra-structures for steam raising and other equipments. The most convenient method of sanitization is the use of chemical compounds such as sodium hypochlorite and bleaching powder which are widely used. Generally 50 to 300 ppm. available chlorine is effective as a sanitizer.

#### 1. SODIUM HYPOCHLORITE (NaOCl)

It is prepared by the electrolysis of sodium chloride solution in a cell where the chlorine is produced at the anode is free to react with sodium hydroxide formed at the cathode. The temperature of the cell is maintained around 300°C.



It is also formed when sodium carbonate is added to a suspension of bleaching powder in water.



Insoluble calcium carbonate is filtered off.

Sodium hypochlorite reacts with dilute acids. Hypochlorous acid formed during the reaction decomposes to yield chlorine.

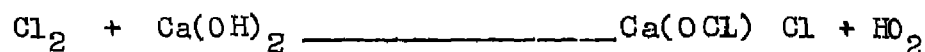
It is thermally unstable. It decomposes even on standing.



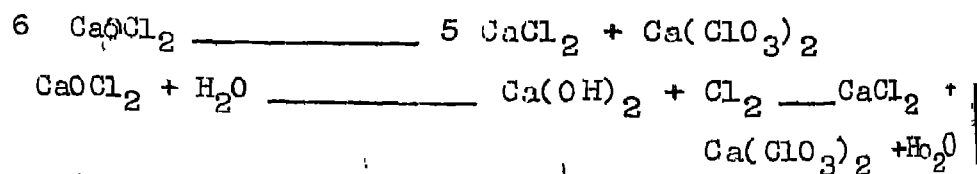
Sodium hypochlorite is available in the form of solution containing 10-12% available chlorine, which is kept as the stock solution to be diluted as required.

## 2. Bleaching Powder ( $\text{CaOCl}_2$ )

Bleaching powder is obtained by passing dry chlorine over dry slaked lime and is usually represented by the formula  $\text{Ca(OCl)Cl}$ . It is considered to be a mixture of calcium chloride and calcium hypochlorite.

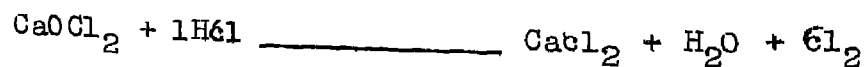


Bleaching powder is a pale yellowish white powder and smells strongly of chlorine. It is not completely soluble in water. It is thermally unstable and decomposes by light, atmospheric moisture and carbon dioxide.



### AVAILABLE CHLORINE

On treatment with dilute acids, bleaching powder gives whole of its chlorine which is known as 'AVAILABLE CHLORINE'.



The commercial bleaching powder contains about 35% available chlorine. Bleaching powder is an important ready source of chlorine.

ANALYSIS OF WATER

Ex-1. To determine the total solids content of water:

Apparatus: Porcelain dish, water bath, pipette 100ml, electric hot air oven, desiccator.

Principle: Non-volatile dissolved substances in water are left as a residue on the evaporation of water.

Procedure: Weigh a clean, dry porcelain evaporating dish

2. Filter a sample of water and collect about 150 ml.
3. Pipette 100 ml of the filtered water into a porcelain dish.
4. Evaporate on a water bath till dry.
5. Wipe the bottom and heat in an electric oven at  $100^{\circ}\text{C}$  for one hour.
6. Cool in a desiccator to room temperature and weigh accurately.
7. Repeat heating, cooling and weighing till a constant weight is reached.

Observations:

1. Weight of the empty porcelain dish =  $x\text{g}$
2. Weight of the porcelain dish & residue obtained by evaporating 100 ml of water =  $y\text{g}$
3. Weight of the residue =  $(y-x)\text{g}$

Calculations: Weight of total solids =  $\frac{(y-x)}{100}\text{g}$   
per ml. of water

$$\begin{aligned}\text{Total solids in parts per million (p.p.m.)} &= \frac{(y-x) \times 1000000}{100} \\ &= (y-x) \times 10^4\end{aligned}$$

Conclusion: The sample of water  
Contains.....p.p.m. of total solids

Exercise 2: To determine the total hardness in the given sample of water.

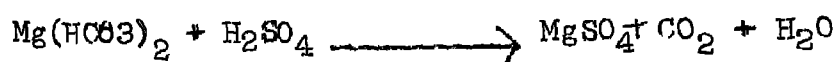
Apparatus: Conical flask, porcelain dish, pipette 100 ml.  
pipette 25 ml, burette, funnel.

Reagents: Sulphuric acid N/10 and N/50, sodium carbonate solution N/10, Sodium hydroxide N/10; methyl red indicator.

Principle: The hardness of water is due to dissolved salts of calcium and magnesium. Hardness is of two kinds - temporary and permanent. Temporary hardness is due to bicarbonates of calcium and magnesium and can be removed by boiling. Permanent hardness is due to sulphates and chlorides of calcium and magnesium and is not removed by boiling.

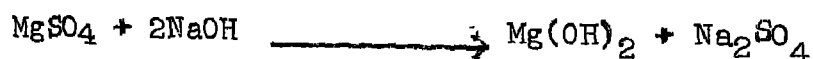
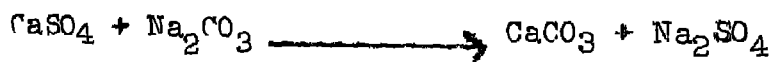
Hardness of water is expressed in terms of calcium carbonate equivalent to the amount of different soluble salts and can be determined by titration with standard acid.

Procedure: A. Estimation of Temporary Hardness Reactions:



1. Pipette 100 ml of filtered water in a 500 ml conical flask.
2. Add a few drops of methyl red indicator.
3. Titrate with N/50 sulphuric acid till the colour changes to red.
4. Boil to drive off the carbon dioxide from the decomposed carbonates and bicarbonates.
5. Note disappearance of red colour during boiling.
6. Continue titration with the same acid while boiling till red colour is permanent.
7. Note the amount of total acid required in titration.

B. Estimation of Permanent Hardness Reactions:



1. Pipette 100 ml of water in a porcelain dish.
2. Add 12.5ml of N/10 sodium carbonate solution to precipitate calcium as calcium carbonate.
3. Add 12.5ml of N/10 sodium hydroxide to precipitate magnesium as magnesium hydroxide.
4. Evaporate on a water bath till the solution is almost dry.
5. Wash the residue with freshly boiled distilled water.



6. Filter through a filter paper and wash the residue thoroughly with some distilled water and collect the filtrate.
7. Titrate the filtrate with N/10 sulphuric acid using methyl red indicator.
8. Repeat the procedure with 100 ml. of distilled water for blank reading.

Observations:

- A. Amount of N/50 sulphuric acid used = x ml.
- B. 1. Amount of N/10 sulphuric acid used by 100 ml of sample water = y ml.
2. Amount of N/10 sulphuric acid used in blank determination = Z ml.
3. Amount of N/10 sulphuric acid actually used for 100 ml of sample water = (Y-Z) ml.

Calculations:

Part - A:

1 ml of N/50 sulphuric acid = 10 parts of calcium carbonate per million

x ml of N/50 sulphuric acid = 10 X x p.p.m. of calcium carbonate

Part - B

1 ml of N/10 sulphuric acid = 50 p.p.m. of  $\text{CaCO}_3$ .

(Y-Z) ml. of N/10 sulphuric acid = (Y-Z) x 50 p.p.m. of calcium carbonate

Total hardness of water = (xX10) + (Y-Z) x 50 p.p.m. of calcium carbonate

Conclusions:

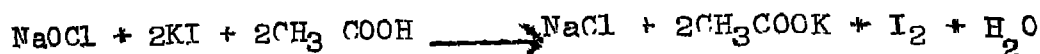
The total hardness of given sample of water is p.p.m. of calcium carbonate.

Experiment Determination of available chlorine in chlorine containing sterilizers.

Apparatus: Conical flask 250 ml. burette 50 ml., pipette 20 ml, measuring cylinder 25 ml.

Reagents: Glacial acetic acid, potassium iodide, sodium thio-sulphate solution N/10, starch solution 1%.

Principle: The sterilisation of equipments - is carried out by hypochlorite or bleaching powder solution when other means of sterilizations are not possible. It is necessary to check the strength of available chlorine in the sterilizer to determine the strength of the chemical. The method is based upon the reaction between hypochlorite solution and acidified potassium iodide.



The liberated iodine is then titrated against N/10 Sodium thiosulphate.



One molecule of sodium thiosulphate is equivalent to one atom of iodine or one atom of chlorine. Its molecular weight as the pentahydrate is 248.2 and N/10 solution contains 24.82g per litre. It follows that every ml. of N/10 solution is equivalent to 0.003546 g available chlorine.

#### Procedure:

1. Pipette 5ml of the sample into a 200 ml volumetric flask and dilute with distilled water to make the volume upto mark.
2. Pipette 50 ml of diluted solution to be tested into a conical flask.
3. Add 2g of potassium iodide crystals to the solution and dissolve them, followed by 10ml of glacial acetic acid.
4. Free chlorine which is liberated from hypochlorite by the action of the acid, produces a yellow colour in the solution by liberating an equivalent amount of iodine from the potassium iodide.
5. Titrate the mixture against N/10 sodium thiosulphate until the brown colour changes to light straw yellow.
6. At this stage add 2ml. of one percent starch solution as indicator, continue titration by addition of thiosulphate solution two drops at a time till the colour disappears.
7. Repeat the experiment to get concordant values.
8. Make a 'blank' determination and deduct the appropriate figure.

#### Observations:

Record the titre values in the tabular form.

1. Strength of sodium thiosulphate =  $f \times \text{N/10}$
  2. Volume of N/10 sodium thiosulphate =  $v$  ml required (after deduction for blanks)
- 1ml. of N/10 sodium thiosulphate 0.003546g available chlorine
- 1 m., of  $f \times \text{N/10}$  sodium thiosulphate =  $f \times 0.003546$ g available chlorine ( $f$ =factor)
- $v$  ml. of  $f \times \text{N/10}$  sodium thiosulphate =  $v \times f \times 0.003546$  g available chlorine

This was contained in 50 ml of diluted solution, or 1 m., of the original sample. Therefore available chlorine in 100 ml. of the sample =  $v \times f \times 0.003546 \times 100$ g or  $v \times f \times 0.3546$  percent.

## Analysis of Detergents:

**Exercise:** To detect the various chemical compounds which are the constituents of the detergents used.

**Apparatus:** Test tubes, water bath, thermometer 0 - 110°C, funnels, filter stand.

**Reagents:** Hydrochloric acid, nitric acid (dilute) oxalic acid, 10% ammonium molybdate solution, 0.05% Benzidine solution, sodium acetate solution, chloroform, sodium chloride, Bromophenol blue, methyl red, clear lime water.

**Principle:** Alkali detergents used in the cleaning and washing operations include caustic soda, sodium carbonate, sodium meta Silicates, Tri-sodium phosphate and synthetics like teepol, acinol, alochol, cetavlon, calgon etc. These detergents contain chemical compounds which can be detected by their characteristics reactions.

**Procedure:** Prepare a 1 percent solution of the detergent in distilled water and carry out the following tests:

2. Take about 10 ml of the above solution in a test tube.
3. **Carbonates and bicarbonates:** Add about 5 ml of dilute hydrochloric acid. Brisk effervescence. The evolved gas, when passed through clear lime water, turning lime water milky indicates the presence of carbonate.
4. **Phosphates:** Add nitric acid to another 10 ml of the sample in a test tube, heat to boiling and cool. Add ammonium molybdate solution and heat to 60°C. Yellow precipitate indicates phosphates.
5. **Silicates:** Filter the solution from the test tube in step 4. Add a little oxalic acid to the filtrate. Add a drop of 0.05 percent benzidine and a little sodium acetate solution. A blue colour indicates silicates.
6. **Soaps:** Take another 10ml of the detergent solution in a test tube. Acidify with dilute hydrochloric acid using methyl red indicator and boil separation of fatty acids layer on top indicates presence of soaps in a detergents. (silica may also separate in this test).
7. **Synthetics:** Remove the fatty acids from the test in step 6, by filtration, ~~shake~~ shake solution violently. A froth indicates synthetics.
8. **Quarternary bases:** Add chloroform, sodium chloride and bromophenol blue to the test solution in step 7. A blue chloroform layer indicates a quarternary ammonium base.

**Exercise:** To estimate the quantity of caustic soda and sodium carbonate in a detergent.

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Apparatus: Pipette 50 ml, 10 ml, 5 ml. burette 50x1/10 ml, conical flask-250 ml, volumetric flask-250 ml.

Reagents: Sulphuric acid N/10, phenolphthalein indicator-0.5% solution, methyl orange indicator -0.5% solution.

Procedure:

1. Weigh accurately one gram of the detergent and dissolve in distilled water and transfer quantitatively into 250 ml volumetric flask and make up the volume upto the mark with distilled water and mix well.
2. Pipette 50 ml of the solution to a 250 ml conical flask.
3. Add a few drops of phenolphthalein indicator.
4. Titrate against N/10 sulphuric acid till the pink colour is discharged. Note the volume of acid used ( A ml ).
5. To the same solution add now a few drops of methyl orange indicator.
6. Continue to titrate with N/10 sulphuric acid until a slight pink colour appears. The volume of acid used in this second titration is noted ( B ml.)
7. Repeat the experiment to get concordant results.

Observations:

Record the titre readings for A and B in the tabular form.

Calculations:

$$\text{Percentage of free caustic} = (A-B) \times 0.4$$

$$\text{Percentage of total alkali} = (A+B) \times 0.4 \text{ (in terms of carbonate)}$$

$$\text{Percentage of carbonate alkalinity} = 2B \times 0.53$$

Conclusion:

The quantities of caustic soda and sodium carbonate in the detergent are \_\_\_\_\_

Harish Chander

Chemistry of some important solvents

The solvents which are most commonly used in the laboratories and industries include the followings;

(1) ALCOHOLS

- (a) Methyl alcohol
- (b) Ethyl alcohol
- (c) Butyl Alcohol
- (d) Amyl alcohols

(2) Ethers

- (a) Diethyl ether (solvent ether)
- (b) Petroleum ether

(3) Chloroform

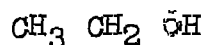
(4) Hexane

(5) Benzene

Methyl alcohol, Ethyl alcohol, Butyl alcohol and Amyl alcohol

An alcohol is a compound that contains one or more hydroxyl group, i.e. alcohols are hydroxy derivatives of the alkanes. Their general formula can be written as  $C_nH_{2n+1}OH$  or  $R OH$ .

Examples are:  $CH_3 OH$



Methyl alcohol

Ethyl alcohol

Hydroxyl group ( $- OH$ ) is the functional group of alcohols.

Alcohols are classified according to the number of hydroxyl groups present.

For example;

- |       |                     |                               |
|-------|---------------------|-------------------------------|
| (i)   | Monohydric alcohols | contain one ----- OH group    |
| (ii)  | Dihydric alcohols   | contain two ----- OH groups   |
| (iii) | Trihydric alcohols  | contain three ----- OH groups |
| (iv)  | Polyhydric alcohols | contain four ----- OH groups  |

Methyl alcohol ( $CH_3 OH$ ), Ethyl alcohol ( $C_2 H_5 OH$ )

Propyl alcohol ( $C_3 H_7 OH$ ), Butyl alcohol

( $C_4 H_9 OH$ ) etc. are the examples of monohydric alcohols. The monohydric alcohols form a homologous series with the general formula  $C_nH_{2n+1} OH$ .

Monohydric alcohols are further classified as primary ( $1^\circ$ ), secondary ( $2^\circ$ ), or tertiary ( $3^\circ$ )

(a) In primary alcohols, the hydroxyl bearing carbon is attached to one other carbon atom. They have straight chain formula.

(b) In secondary alcohols, the hydroxyl bearing carbon is attached to two other carbon atoms. They have branched chain formula.

(c) In tertiary alcohols, the hydroxyl bearing carbon is attached to three other carbon atoms. They also have branched chain formula.

Examples of primary, secondary and tertiary alcohols are given below:

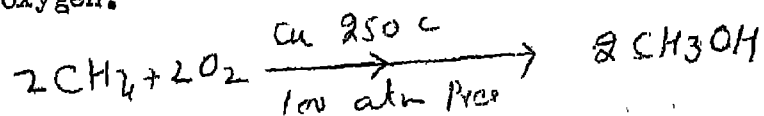
	Primary	Secondary	Tertiary
general formula	$R-CH_2-OH$	$R-\underset{\substack{  \\ R_1}}{CH}-OH$	$\begin{array}{c} R^1 \\   \\ R-\underset{\substack{  \\ R}}{C}-OH \\   \\ CH_3 \end{array}$
specific example	$CH_3CH_2CH_2-OH$	$CH_3-\underset{\substack{  \\ CH_3}}{CH}-OH$	$CH_3-\underset{\substack{  \\ CH_3}}{C}-OH$
	n-propyl alcohol	Iso-propyl alcohol	t-butyl alcohol

### Methyl alcohol ( $CH_3OH$ )

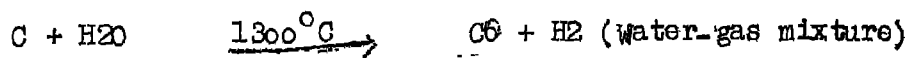
It is also known as Methanol or Carbinol, wood alcohol or wood spirit. It is the simplest possible representative of the alcohol class.

The methanol can be manufactured in three ways :

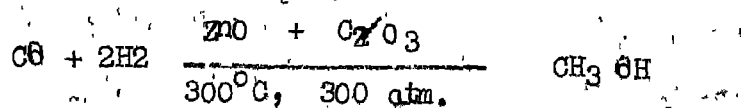
- (i) From Methane: By oxidation of methane with limited amount of oxygen.



- (ii) From water Gas: Water gas is a mixture of carbon monoxide and hydrogen. It is obtained by passing steam over red hot coke.



The water gas is mixed with more hydrogen and passed over a heated catalyst of zinc and chromium oxides.



(iii) From pyroligneous Acid

Pyroligneous acid is obtained from the destructive distillation of wood. It contains methanol, acetone and acetic acid and all the three compounds can be obtained by suitable treatment. It was this method, which gave rise to the name 'wood spirit' for methanol.

Methanol is a colourless, inflammable liquid, boiling point  $64^{\circ}\text{C}$ , and is poisonous. It is miscible with most organic solvents. It burns with a faintly luminous flame, and its vapour forms explosive mixtures with air or oxygen when ignited.

Methanol is used as a solvent for many purposes e.g. paints, varnishes, celluloid cement etc., in the manufacture of dyes, perfumes formaldehyde etc. It is also used for making methylated spirit and auto mobile antifreeze mixtures. Methylated spirit is denatured ethyl alcohol i.e. methanol is added to ethyl alcohol to denature it and render it unfit for drinking purposes.

Ethyl alcohol ( $\text{C}_2\text{H}_5\text{OH}$ )

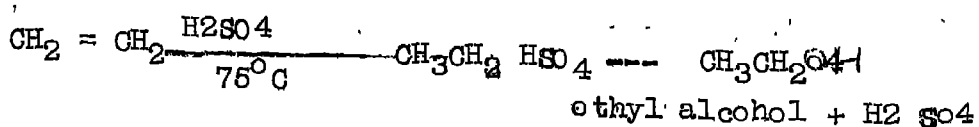
Ethyl alcohol is also known as Ethanol and is commonly called 'alcohol' for all purposes.

Ethyl alcohol can be manufactured in the following ways:

1. From Ethylene: There are two ways:

(a) Sulphuric acid process: Ethylene is treated with conc.

$\text{H}_2\text{SO}_4$  at  $75^{\circ}\text{C}$  to give ethyl hydrogen sulphate which is then hydrolysed with water to give ethyl alcohol.

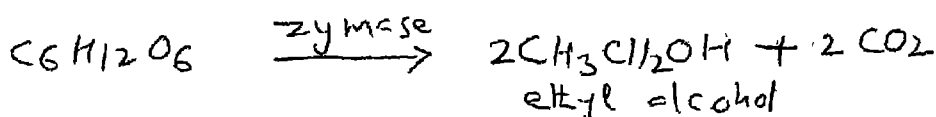
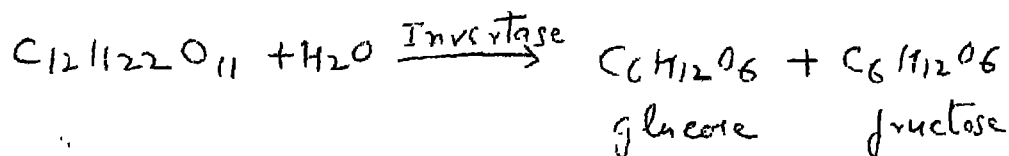


(b) Phosphoric acid process: Ethylene is treated with water in the presence of phosphoric acid.



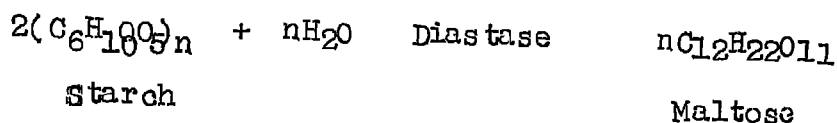
2. From molasses (By fermentation)

Molasses is the mother liquor left after the crystallisation of cane sugar from concentrated juice i.e. molasses is obtained as by product from sugar industry. It is dark coloured thick syrupy mass. Molasses contains about 60% fermentable sugars, mostly sucrose, glucose, and fructose. Molasses is converted into ethyl alcohol through the process of fermentation with two yeast enzymes (Invertase and zymase) as shown in the following steps:

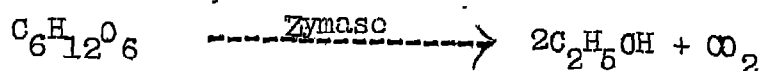
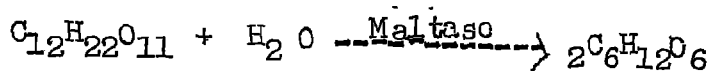


3. From Starch (By fermentation)

The important raw materials containing starch are potatoes, rice, wheat, and barley. The raw material e.g. wheat or barley, is mashed with hot water, and then heated with malt (germinated barley) at 50°C for 1 hour. Malt contains the enzyme diastase which by hydrolysis, converts starch into the sugar called maltose.



The liquid is then cooled to 30°C and fermented with yeast for 1-3 days. The yeast used contains various enzymes, among which are maltase and zymase. Maltase enzyme converts maltose into glucose and zymase enzyme converts glucose into ethanol;



The carbon dioxide is recovered and sold as a by product. The fermented liquor or ( 'wort' which contains 6-10 percent ethanol and some other compounds, is fractionated into three fractions:

- i) First fraction which consists mainly of acetaldehyde.
- ii) second fraction Rectified spirit ----- which is 93 - 95 percent w/w ethanol.
- iii) Final fraction ----- also called fusel oil ----- which contains n-propyl, n-butyl, isobutyl, n-amyl, iso amyl and 'active' amyl alcohol.

Industrial alcohol is ordinary rectified spirit.

Methylated spirit is of two kinds:

- a) Mineralised methylated spirit : which is 90% rectified spirit, 9% methanol and 1% petroleum oil, and a purple dye.

- b) Industrial methylated. Spirit;

which is 95% rectified spirit and 5% methanol whose purpose is to denature the rectified spirit.

## Denatured Alcohol

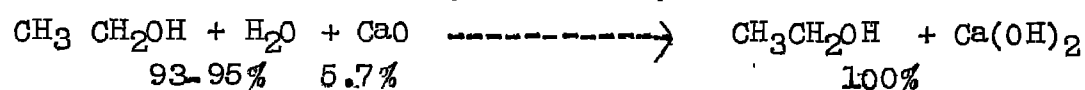
Denatured alcohol is a commercial alcohol to which small amounts of poisonous substances (such as methyl alcohol or pyridine) have been added. This is done to make it unfit for human consumption.

## Absolute Alcohol

Absolute alcohol is 100% pure ethyl alcohol. It can be prepared from rectified spirit (commercial alcohol) which is a mixture of 93-95% ethyl alcohol and 5.7% water. This mixture can not be separated by further distillation.

Absolute alcohol (water-free ethyl alcohol) is obtained as follows:

Quick lime (CaO) is added to the commercial alcohol. The mixture is refluxed for eight hours. It is then distilled to give absolute alcohol.



## Properties of ethanol

Ethanol is a colourless, inflammable liquid. It has boiling point of  $78.1^\circ\text{C}$ , and has characteristic odor. It is miscible with water in all proportions, and is also miscible with most of the organic solvents.

Ethyl alcohol is mainly used :

- (i) As an important beverage.
- (ii) As a fuel in spirit lamps.
- (iii) As a solvent for dyes, drugs, tinctures, paints, varnishes etc.
- (iv) As a preservative for biological specimens.
- (v) In scientific apparatus like thermometers and spirit levels.

- (vi) As a starting material for the preparation of ether, chloroform, iodoform, acetaldehyde and ethyl chloride.
- (vii) As an important reaction medium and extracting solvent in organic chemistry.

Butyl alcohol  $- (C_4H_9OH)$

Butyl alcohol has four isomers :

- (i) Normal Butyl alcohol  $- CH_3(CH_2)_2 CH_2OH$
- (ii) Secondary Butyl alcohol  $- CH_3 CH_2 CH(OH) CH_3$
- (iii) Iso-butyl alcohol  $- (CH_3)_2 CHCH_2OH$
- (iv) Tertiary butyl alcohol  $- (CH_3)_3 C - OH$

Butyl alcohol is a colourless liquid with a characteristic odour. It is moderately soluble in water, and miscible with alcohol or ether.

It is obtained when starch and sugars are fermented with a special bacillus. It is also produced synthetically.

It is widely used as a solvent.

#### Amyl alcohols

Eight isomers are possible :

1.  $CH_3CH_2CH_2CH_2 CH_2OH$  - n - amyl alcohol or pentan-1-ol, n-pentanol boil point (b.p.)  $-138^\circ C$
2.  $(CH_3)_2 CH CH_2 CH_2OH$  - iso amyl alcohol or iso-pentanol, b.p.  $130^\circ C$ .
3.  $CH_3CH_2 CH(CH_3) CH_2OH$  - 'active' amyl alcohol or 2-methyl butan-1-ol, b.p.  $128^\circ C$ .
4.  $(CH_3)_3 C CH_2OH$  - neopentyl alcohol, b.p.  $113^\circ C$ .
5.  $CH_3 CH_2 CH_2 CH (OH)CH_3$  - pentan-2-ol, b.p.  $120^\circ C$ .
6.  $CH_3CH_2 CH(OH) CH_2CH_3$  - pentan-3-ol, b.p.  $117^\circ C$ .
7.  $(CH_3)_2 CH CH (OH) CH_3$  - 3-methyl butan-2-ol; b.p.  $114^\circ C$
8.  $(CH_3)_2 C(OH) CH_2 CH_3$  - 2-methyl butan-2-ol, or t - amyl alcohol or t-pentanol

Amyl alcohols are isolated from fusel oil. Among these iso-amyl alcohol predominates. These amyl alcohols are widely used as solvents.

#### Use of iso-amyl alcohol in the dairy industry

Iso-amyl alcohol ( $\text{CH}_3-\underset{\text{CH}_3}{\text{C}}\text{H}-\text{CH}_2-\text{CH}_2\text{OH}$ ) is very often used in the dairy industry for the estimation of fat by the most common volumetric method called Gerber method. This method is based upon the principle that when a definite quantity of Gerber sulphuric acid and iso-amyl alcohol are added to a definite volume of milk, the proteins will be dissolved and the fat globules will be set free which remains in the liquid state due to heat produced by the acid. On centrifugation fat being lighter will be separated on the top of the solution. In this method, addition of small amounts of amyl alcohol helps in the separation of fat.

#### Diethyl Ether

##### Ethers:

The general formula of the ethers is  $\text{C}_n\text{H}_{2n+2}\text{O}$  (which is the same as that for the monohydric alcohols).

Their general structure is  $\text{R}-\text{O}-\text{R}$ . When the two alkyl (R) groups in an ether are the same, the ether is said to be symmetrical or simple, e.g., dimethyl ether,  $(\text{CH}_3-\text{O}-\text{CH}_3)$ , and diethyl ether,  $\text{C}_2\text{H}_5-\text{O}-\text{C}_2\text{H}_5$ . When the two alkyl groups are different, the ether is said to be unsymmetrical or mixed e.g. ethyl methyl ether,  $\text{CH}_3-\text{O}-\text{C}_2\text{H}_5$ .

Ethers can be named in two ways:

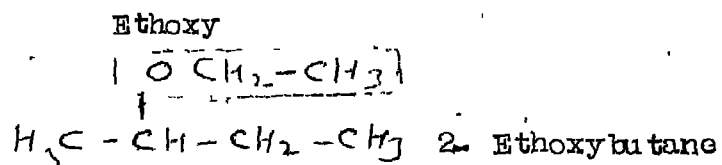
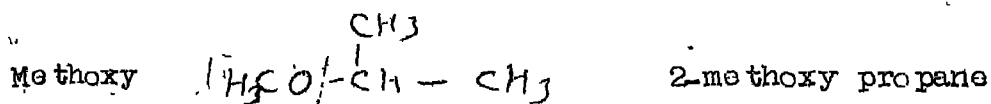
##### (1) Common system

The two alkyl groups attached to the oxygen atom are named in alphabetic order and the word ether is added. If the groups are same ( $\text{R}-\text{O}-\text{R}$ ), then the prefix di- is used.

$\text{CH}_3\text{OCH}_3$	Dimethyl ether
$\text{CH}_3\text{CH}_2\text{CH}_3$	Ethyl methyl ether
$\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$	Diethyl ether

(2) IUPAC system

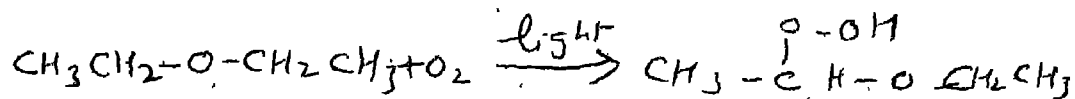
In this system, ethers are named as Alkoxyalkanes. The smaller alkyl group with the oxygen atom is called an alkoxy substituent.



Among the different ethers, diethyl ether has the maximum application in many fields. It is also called solvent ether.

Properties of Diethyl ether

Diethyl ether is a colourless, volatile and pleasant smelling liquid. Its boiling point is  $34.5^\circ\text{C}$ . It is fairly soluble in water, and is miscible with ethanol in all proportions. It is highly inflammable. On exposure to sunlight and air, it forms explosive mixture (peroxides) due to oxidation.



Diethyl ether

Peroxide of diethyl ether.

This is a great disadvantage in its use as an industrial solvent for oils, fats etc. Oxidation of this type can be avoided by storing ethers in dark, well-sealed bottles.

Diethyl ether is lighter than water, diethyl ether is weakly polar in nature as explained below:

The C-O-C bond angle in ethers is about  $110^\circ$  and as

such the dipole moment of one C-O bond does not cancel out the dipole moment of the other bond. The result is that an ether molecule possess a small net dipole moment.



The molecule posses a net dipole moment.

The weak polarity of ethers does not, however, affect their boiling points significantly.

The fair amount of solubility of hydrogen bonds between water and ether molecules.

#### Uses of Diethyl ether

Diethyl ether is by far the most useful of all ethers.

It is used ;

- (i) As an industrial solvent for oils, fats, gums etc., and as an extracting solvent.
- (ii) As a refrigerant
- (iii) As a general anaesthetic in surgery.
- (iv) As a usual solvent for many reactions.

#### Petroleum ether

Petroleum ether also called Ligroin, is a term used for low boiling petroleum solvent.

#### Petroleum ?

Petroleum (crude oil) is a black oily liquid found underground in porous rocks. It consists of alkanes, mainly in the  $C_5 - C_{40}$  range, with small amounts of cycloalkanes, aromatic Hydrocarbons, and compounds containing nitrogen, sulphur, and

oxygen. petroleum is believed to have been formed over a period of millions of years by the bacterial decomposition of marine plants and animals.

petroleum ether is a fraction obtained from the fractional distillation of petroleum (crude oil). The composition of petroleum ether, in which hydrocarbons from butane to octane predominate, varies with the boiling point. In general, the grades sold are those boiling at  $40 - 60^{\circ}\text{C}$ ,  $60 - 80^{\circ}\text{C}$ ,  $80 - 100^{\circ}\text{C}$  etc. It is used as a solvent, particularly for fatty materials. The term petroleum benzine is also sometimes used for petroleum ether which means this class of solvent, but the term is sometimes more broadly used to include less volatile, solvents, it is a confusing term which is no longer used industrially.



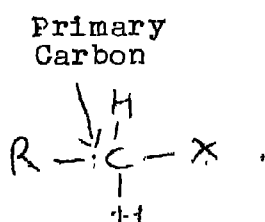
Chloroform (CHCl<sub>3</sub>)

Chloroform comes under the category of compounds called alkyl Halides.

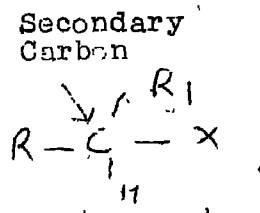
Alkyl halides are those compound which contain carbon-halogen bonds. Their general formula is R-X where R- Alkyl group and X-Cl, Br, I or F. Examples are :

CH<sub>3</sub>Br Methyl bromide  
 CH<sub>3</sub>CH<sub>2</sub>I Ethyl Iodide  
 CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>Cl n - propyl chloride  
 CHCl<sub>3</sub> Chloroform or Trichloro methane

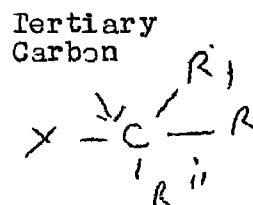
Alkyl halides may be classified as primary (1°), Secondary (2°), or tertiary (3°), depending upon whether the halogen atom is attached to a primary, secondary, or tertiary carbon.



1° Alkyl halide



2° Alkyl Halide



3° Alkyl halide

These halogen derivatives of alkanes i.e. alkyl halides are further classified depending upon the number of halogen atoms present in the molecules, as follows :

Mono halogen derivatives : Containing one halogen atom

Examples : C<sub>2</sub>H<sub>5</sub>Cl Ethyl chloride

CH<sub>3</sub>CHBrCH<sub>3</sub> iso propyl bromide

Dihalogen derivatives : Containing two halogen atoms.

Examples :

CH<sub>2</sub>CHBr<sub>2</sub> ethylidene dibromide

CH<sub>3</sub>CCl<sub>2</sub>CH<sub>3</sub> iso propylidene dichloride

CH<sub>2</sub>ClCH<sub>2</sub>Cl ethylene dichloride

oxygen. petroleum is believed to have been formed over a period of millions of years by the bacterial decomposition of marine plants and animals.

petroleum ether is a fraction obtained from the fractional distillation of petroleum (crude oil). The composition of petroleum ether, in which hydrocarbons from butane to octane predominate, varies with the boiling point. In general, the grades sold are those boiling at 40 - 60°C, 60 - 80°C, 80 - 100°C etc. It is used as a solvent, particularly for fatty materials. The term petroleum benzine is also sometimes used for petroleum ether which means this class of solvent, but the term is sometimes more broadly used to include less volatile, solvents, it is a confusing term which is no longer used industrially.

Chloroform ( $\text{CHCl}_3$ )

Chloroform comes under the category of compounds called alkyl Halides.

Alkyl halides are those compound which contain carbon-halogen bonds. Their general formula is  $\text{R-X}$  where R- Alkyl group and X-Cl, Br, I or F. Examples are :

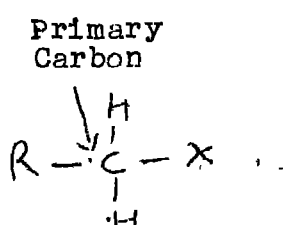
$\text{CH}_3\text{Br}$  Methyl bromide

$\text{CH}_3\text{CH}_2\text{I}$  Ethyl Iodide

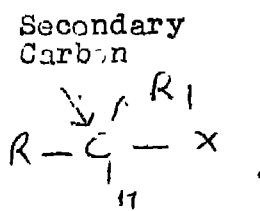
$\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$  n - propyl chloride

$\text{CHCl}_3$  Chloroform or Trichloro methane

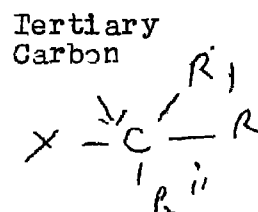
Alkyl halides may be classified as primary ( $1^\circ$ ), Secondary ( $2^\circ$ ), or tertiary ( $3^\circ$ ), depending upon whether the halogen atom is bonded to a primary, secondary, or tertiary carbon.



$1^\circ$  Alkyl halide



$2^\circ$  Alkyl Halide



$3^\circ$  Alkyl halide

These halogen derivatives of alkanes i.e. alkyl halides are further classified depending upon the number of halogen atoms present in the molecules, as follows :

(i) Mono halogen derivatives : Containing one halogen atom.

Examples :  $\text{C}_2\text{H}_5\text{Cl}$  Ethyl chloride

$\text{CH}_3\text{CHBrCH}_3$  iso propyl bromide

(ii) Dihalogen derivatives : Containing two halogen atoms.

Examples :

$\text{CH}_2\text{CHBr}_2$  ethylidene dibromide

$\text{CH}_3\text{CCl}_2\text{CH}_3$  iso propylidene dichloride

$\text{CH}_2\text{ClCH}_2\text{Cl}$  ethylene dichloride.

(iii) Trihalogen derivatives : Containing three halogen atoms :

Examples :

$\text{CHCl}_3$  Chloroform (Trichlore methane)

$\text{CHBr}_3$  Bromoform

$\text{CHI}_3$  Iodoform

(iv) Tetra halogen derivatives : Containing four halogen atoms.

Example :  $\text{CCl}_4$  Carbon tetrachloride

$\text{CHCl}_2\text{CHCl}_2$  Tetra chlore ethane

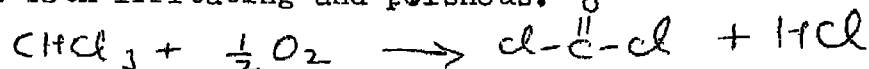
As explained above, chloroform is a example of Trihalogen derivative of alkyl halides. Among the various alkyl halides, Chloroform is by far the most important which has many uses.

#### Properties of Chloroform

Chloroform is a colourless liquid with a characterstic sweetish odour. When its vapour is inhaled, it causes unconsciousness. It is slightly soluble in water, and miscible with alcohol or ether. Its boiling point is  $61^\circ\text{C}$ .

Chloroform is non-inflammable, but the vapour in contact with flame or with air in presence of light form an oxidation product i.e. Carbonyl chloride ( $\text{COCl}_2$ ) also called phosgene.

Phosgene is both irritating and poisonous.



To prevent the formation of phosgene the chloroform should be stored in dark bottles and tightly closed.

#### Uses of chloroform.

- (1) As a general anaesthetic, although its use for this purpose is being discarded because of its bad effect on the heart,
- (2) As a solvent for fats, waxes, resins etc.
- (3) As a laboratory reagent
- (4) As a preservative for anatomical specimens.
- (5) In medicines
- (6) In the preparation of chloropicrin which is used as an insecticide.

### Hexane

Hexane belongs to a group of compounds known as ALKANES. Alkanes are hydrocarbons that contain only single bonds. They can be represented by the general formula  $C_nH_{2n+2}$ , where  $n$  is the number of carbon atoms in the molecule.

Examples are :

$CH_4$  - Methane ,  $CH_3CH_3$  - Ethane

$CH_3CH_2CH_3$  - Propane,

$CH_3CH_2CH_2CH_2CH_2CH_3$  - Hexane etc.

Hydrocarbons or alkanes are derived from petroleum and have only carbon and hydrogen. Alkanes are also called paraffins (Latin parum affinis - little affinity). This is because they contain strong C - C bond and C - H bonds and are not very reactive.

The first four members of the alkane homologous series are called by their common names (trivial names) : methane, ethane, propane, and butane. The name of larger alkanes are derived from the Greek prefixes that indicate the number of Carbon atoms in the molecule. Thus pentane has five carbons, hexane has six, and so forth. Their systematic names are given on the basis of IUPAC (International Union of Pure and Applied Chemistry) system.

The first five members of the alkanes series i.e. methane, ethane, propane butane & pentanes occur in nature in the natural and petroleum gas form. While Hexane and other higher alkanes exist in the solvent form.

Hexane is one of the important alkane and as explained earlier it is derived from petroleum by the fractional distillation. It is a colourless liquid. It is widely used as a solvent for extraction of fat etc. in the laboratories and Industries.

Benzene -  $C_6H_6$

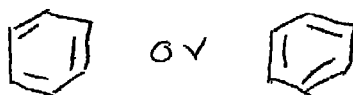
Benzene, also called Benzol, is the simplest of the common cyclic or aromatic hydrocarbons.

What are aromatic hydrocarbons ?

Early in the development of organic Chemistry, organic compounds were arbitrarily classified as either aliphatic or aromatic. The aliphatic compounds were so named because the first members of this class to be studied were the fatty acids. The term aliphatic is now reserved for any compound that has an open-chain structure.

In addition to the aliphatic compounds, there was a large number of compounds which were obtained from natural sources, e.g. resins, balsams, 'aromatic' oils, etc., which comprised a group of compounds whose structures were unknown but had one thing in common a pleasant odour. Thus these compounds were arbitrarily known as aromatic (Greek : aroma fragrant smell). Careful examination of these compounds showed that they contained a higher percentage of carbon than the corresponding aliphatic hydrocarbons, and that most of the simple aromatic compounds contained at least six carbon atoms. Further more, it was shown that when aromatic compounds were subjected to various methods of treatment, they often produced benzene or a derivative of benzene.

Benzene is also known as 'phene' & has the following structure :



Benzene ( $C_6H_6$ )

Benzene is obtained by the destructive distillation of Coal by the fractionation of Coal - tar distillate, followed by purification. Apart from this, benzene can also be prepared in the laboratory by different methods.

### Properties and uses of Benzene

Benzene is a colourless, volatile liquid with a peculiar smell. It is inflammable, burning with a smoky flame due to the high carbon content. It is insoluble in water but miscible with alcohol or ether. The structure of benzene ( $C_6H_6$ ) suggests that it is a highly unsaturated compound.

It is a very good solvent for fats, resins, sulphur, iodine, etc., and is used in dry cleaning. It is also used as a motor fuel ('benzol') and for the manufacture of nitrobenzene, dyes, drugs, etc.

Preparation of Common Laboratory reagents

1) Acetic Acid Solution (Approx. 6N)

Glacial acetic acid is approximately 17N. Dilute 1 part of acid with 2 parts of water. This solution will be approximately 6N.

2) Alcohol - Alizarin solution

Dissolve 0.2 gm of alizarin powder in 100 ml of 75 per cent ethyl alcohol.

3) Ammonium Acetate solution (Approx. 3N)

i) Dissolve 231 gm of ammonium acetate in 1 litre of water or (ii) Dilute 300 ml of conc. acetic acid with 300 ml distilled water and neutralize with conc. ammonia and dilute to 1 litre.

4) Ammonium Carbonate (Approx. 6N)

Dissolve 200 gm of solid ammonium carbonate in 350 ml of ammonium hydroxide and dilute to 1 litre with distilled water.

5) Ammonium hydroxide solution (Approx. 6N)

Conc. ammonia is about 15 N. Dilute 2 parts of conc. ammonia with 3 parts of water. The solution is approximately 6 N.

6) Ammonium Molybdate

Dissolve 50 gm of 85 molybdic acid in 120 ml of water and 70 ml of ammonium hydroxide. Filter, Add 30 ml of conc nitric acid and cool. Add the solution with constant stirring to a mixture of 200 ml of Conc. nitric acid and 480 ml of water. Filter the solution before use.

7) Ammonium oxalate (0.5 N solution)

Dissolve 35 gm of ammonium oxalate in distilled water and make up to 1 litre.

8) Barium Chloride (1 N solution)

Dissolve 122 gm of crystalline barium chloride in distilled water and make up to 1 litre.

9) Cupric sulphate (0.5 N Solution)

Dissolve 63 gm of cupric sulphate in distilled water and make up to 1 litre.



10) Ferric chloride (3 N solution) Date.....

270 gm of ferric chloride are dissolve per litre of solution with sufficient quantity of conc. HCl to prevent hydrolysis.

11) Fehling's Solution

Fehling's solution is made by mixing equal amounts of Fehling A and Fehling B.

a) Fehling A is copper sulphate solution. Dissolve 34.369 gm of crystalline copper sulphate ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ) in distilled water and dilute to 500 ml and filter through prepared asbestos.

b) Fehling B Solution

Fehling B is the alkaline solution of sodium potassium tartrate (Rochelle salt). Dissolve 173.0 gm of Rochelle salt in about 300 ml of distilled water. In another beaker dissolve 50 gm of sodium hydroxide in about 100 ml of distilled water. Mix the two solution and make up the volume to 500 ml with distilled water; allow to stand for 2 days and filter through prepared asbestos.

12) Hydrochloric acid (Approx. 2N)

Conc. HCl is about 12 N. Dilute 1 litre of conc. HCl with distilled water and make up to 6 litres to get 2'N.

13) Iodine solution (0.01N solution)

Dissolve 1.3 g of iodine in distilled water with sufficient quantity of potassium iodide and make up to 1 litre.

14) Mercuric Chloride solution (0.4 N solution)

Dissolve 54 gm of mercuric chloride in distilled water and make up to 1 litre.

15) Mercuric Nitrate

Dissolve 10 gm crystalline mercuric nitrate per 100 ml of distilled water and add 1 ml of conc. nitric acid.

16) Nitric Acid (Approximately 6 N) Solution

Concentrated nitric acid is approx. 15 N. Dilute conc. acid

17) Potassium Chromate solution

5 aqueous solution.

18) Potassium Iodide (1N solution)

Dissolve 166 gm of potassium iodide in distilled water and make up to 1 litre.

19) Dissolve 9.7 gm of potassium thiocyanate in distilled water and make up to litre.

20) Rosaniline Acetate (Aqueous Solution)

Solution A (stock solution)

i) Dissolve 0.12 gm of rosaniline acetate in approximately 50 ml of ethyl. alcohol (95-95) containing 0.5 ml of glacial acetic acid; make up to 100 ml with ethyl alcohol.

Solution B (working solution)

ii) Dilute 1 ml of solution A to 500 ml with a mixture of ethyl alcohol (95-96) and distilled water in equal proportions by volume.

Note : - Solution A and B should be stored in dark bottles securely stoppered with rubber bands.

21) Silver Nitrate (0.1 N solution)

Dissolve 15.8 gm of silver nitrate in dist. water and make up to 1 litre.

22) Sodium Carbonate (3 N solution)

Dissolve 159 gm of crystalline sodium carbonate in distilled water and make up to 1 litre.

23) Sodium phosphate (10 solution)

Dissolve 10 gm of crystalline disodium monohydrogen phosphate

24) Acid mercuric nitrate solution

Dissolve mercury in twice its weight of strong nitric acid and dilute with an equal volume of distilled water.

25) Mercuric iodide solution

Dissolve 33.2 gm potassium iodide and 13.5 gm of mercuric chloride in 20 ml of glacial acetic acid and 60 ml of distilled water.

APPENDIX-I

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12. Dr. R.N. Tripathy,  
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13. Dr. S.B. Singh,  
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Ajmer.

14. Prof. B. Ganguly,  
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N.C.E.R.T.
15. Prof. A.K. Misra,  
N.C.E.R.T.
16. Prof. B.D. Atreya,  
D.E.S.M.
17. Dr. A.K. Sacheti,  
N.C.E.R.T.
18. Dr. B. Parkash,  
DESM.
19. Dr. K. Mittal,  
DESM.
20. Dr. S.B. Malik  
(Co-ordinator).

APPENDIX II

Dairying

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Dr. Darshan Lal  
Dr. B.S. Bector  
Dr. D.P. Goel

Crop Production.

Dr. C.P. Ghonsikar  
Dr. Srinivas Sharma  
Dr. N.N. Sharma  
Dr. A.K. Socheti  
Dr. C.G. Misra

Photography

Dr. P.S. Pandey  
Dr. M.C. Aggarwal  
Dr. S.B. Singal  
Mr. V.K. Jain.

Lab Technician

Dr. R.N. Tripathi  
Dr. B.D. Atreya  
Dr. B. Prakash  
Dr. (Mrs.) K. Mittal  
Dr. (Mrs.) S.B. Malik



APPENDIX -III  
Supplementary reading material in chemistry in the  
light of requirement of professional/vocational courses

An approach paper

The present system of education provides an option to the students after class X to opt for either academic stream or vocational stream in plus two stage of education.

Vocational courses have been formulated by various states based on the availability of facilities, technical know-how, raw materials and use of the end product. The aims and objectives of these vocational courses are to develop in pupils a basic background of scientific knowledge along with the specified skills. This is the main difference between the vocational courses and T.T.I. courses where the main emphasis is only on development of certain skills.

Chemistry is a subject of applied nature. There are a large number of vocations based on chemistry. A definite knowledge of chemistry is required to understand clearly a chemistry-based vocation. The books developed for academic courses are generally used for vocational courses. These do not provide the required background of knowledge for the vocation concerned.

The present project has been undertaken keeping in view the need that the material developed for any vocation should be interesting.

The Karnataka State syllabi for all vocational courses were analysed for their chemistry component and the following vocations were selected for the development of supplementary reading materials in chemistry.

- (1) Dairying (2) Crop production (3) Laboratory technician  
(4) Photography (5) Sugar technology.

NCERT syllabus for these vocations was analysed and would be made available to workshop participants.

The following format is suggested for the development of instructional material.

1. Introduction : Some general information about the nature of vocation, its need and status, the potentiality of its expansion in our country, relationship with academic disciplines especially chemistry will be provided here.
2. Chemistry content necessary for the vocation concerned will be spelt out (theory as well as practical) and its distribution amongst chapters would be shown. Time allocation for covering this content will also be suggested.
3. For the development of each chapter the following sections are suggested :
  - a) Overview : It would indicate in brief the coverage of chemistry content of the chapter, mentioning how this content would be useful for the practise of the vocation concerned.
  - b) Recent development - some interesting information about new technologies or research findings in respect of that vocation, with emphasis on Indian context will be provided here . The main purpose of this section is motivational.
  - c) Bridge material for an understanding of the chemistry content of this vocational course : This section will provide a base for the next section, and may be included, if necessary.
  - d) Chemistry content of the vocational course :  
It would include suitable material for an understanding of the chemistry content, as spelt out in section (2). Suitable information about demonstrations, students' experiments, teaching aids etc., will be provided.



- e) Evaluation : Items for evaluation on chemistry content may be included here.
- f) Reference.

Let us take, for example, the vocation 'Crop Production'. The 'Introduction' of the supplementary reading material will provide information about the 'green revolution' how it was brought about in our country, the role of scientific research, including that in chemistry. The main purpose of this section would be motivational.

The next section may spell out the chemistry content for this vocation and organise that into such chapters as : Fertilisers, pesticides, safe storage of Crops (role of chemistry )

Each chapter may then be further discussed as suggested above.

## APPENDIX IV

### MINIMUM VOCATIONAL COMPETENCIES BASIC CURRICULUM DAIRYING

Knowledge	skills	Personality traits
3	4	5
Sanitation and nutrition of calf	- Cleaning of calf	- Cleanliness
Role of colostrum, weaning	- Handling of calf - Cutting and sealing of navel cord.	- Carefulness - Vigilance
	- Weighing of calf	
Materials for housing	- Preparation of concentrate mixtures,	- Skillfulness
Types of feeds and their classification.	- Preparation of mineral mixture.	- Dignity of labour
Functions of water in the body.		
Composition of milk	- Milk Testing	
Factors affecting milk production.		

2	3	4	5
Clean milk production and its handling	<ul style="list-style-type: none"> <li>- Factors affecting clean production,</li> <li>- Composition of milk</li> <li>- Bacteriological and chemical quality of milk,</li> </ul>	<ul style="list-style-type: none"> <li>- Platform test</li> <li>- Fat test</li> <li>- Lactometer reading</li> <li>- Acidity test</li> <li>- Clot on-boiling test</li> <li>- Sediment test</li> <li>- Bacteriological test</li> <li>- Methylene blue reduction test,</li> <li>- Field and laboratory tests for mastitis,</li> <li>- Cleaning and sterilization of udders,</li> </ul>	<ul style="list-style-type: none"> <li>- Personal hygiene</li> <li>- Cleanliness</li> <li>- Accuracy</li> <li>- Skillfulness</li> <li>- Hard work</li> </ul>
Identification of animal on Oestrus,	- Silent heat		
Collection, evaluation and processing of semen,	<ul style="list-style-type: none"> <li>- Factors affecting preservation</li> </ul>	- Preservation	
Artificial insemination	- Hormones related to reproduction		- Fertility
First aid to common ailments and prophylaxis against common diseases	<ul style="list-style-type: none"> <li>- Preventive measures against common diseases,</li> <li>- First aid to animal</li> </ul>		

1	2	3	4	5
3.1.18	Disposal of dead	<ul style="list-style-type: none"> <li>- Disinfection of place</li> <li>- Removal of skin of dead animal</li> </ul>	<ul style="list-style-type: none"> <li>- Visit to Veterinary Hospital for demonstration of post mortem, skin removal and disposal.</li> </ul>	<ul style="list-style-type: none"> <li>- Sturdiness</li> <li>- Diligence of labour</li> <li>- Carefulness.</li> </ul>
3.1.19	Assisting in scientific research,	<ul style="list-style-type: none"> <li>- Feeding and management of experimental animals</li> <li>- Sampling of test material including collection of blood samples.</li> <li>- Recording of basic data</li> </ul>	<ul style="list-style-type: none"> <li>- Collection of blood, milk, duodenum and urine samples.</li> <li>- Collection of feeds and forage samples</li> <li>- Weighing and measurements of animals.</li> <li>- Recording of meteorological data</li> </ul>	<ul style="list-style-type: none"> <li>- Honesty</li> <li>- Diligence</li> <li>- Initiative</li> <li>- Willingness</li> </ul>
3.2.9	Receiving, evaluation and handling of milk,	<ul style="list-style-type: none"> <li>- Sampling procedure</li> <li>- Composition and quality of milk.</li> <li>- Milk adulterants,</li> </ul>	<ul style="list-style-type: none"> <li>- Sampling</li> </ul>	<ul style="list-style-type: none"> <li>- Sincerity</li> </ul>
3.3.1	Sterilizing artificial inoculation equipment	<ul style="list-style-type: none"> <li>- Use and availability of detergents and sanitizers</li> <li>- Sterilization of A.I. equipment.</li> </ul>	<ul style="list-style-type: none"> <li>- Sterilization of equipment</li> <li>- Sterilization of media</li> </ul>	<ul style="list-style-type: none"> <li>- Cleanliness</li> </ul>

1	2	3	4	5
3.3.4	Preservation semen	- Principles and procedure for storage of semen.	- Preservation of chilled semen	Vigilant
3.3.5	Transport of semen	- Source and availability of liquid nitrogen.  - Handling and transport of liquid nitrogen.	- Handling of liquid	- Carefulness
3.4.3	Maintenance and upkeep of stores	- Protection measures against pests, rodents, fire and theft. - Precautions in the use of pesticides and rodenticides	- Identification of common pesticides and rodenticides.  - Methods of their application.	- Honesty - Efficiency - Sincerity  - Hardwork
3.4.4	Sampling and analysis of food ingredients	- Methods of sampling - procedure and methods of physical and chemical analysis.	- physical and chemical - Preparation of common reagents.	- Comprehension - Precision
3.5.1	Procurement of seeds and other inputs.	- Types of manures and fertilizers - important pesticides.	- Identification of seeds fertilizers and pesticides	- Discerning
3.5.2	Sending soil and water  Samples for analysis	- Methods of sampling  - Samples collection  Processing of samples for despatch.	- Sample collection,	- Carefulness

1	2	3	4	5
3.5.4	Application of manures and fertilizers,	<ul style="list-style-type: none"> <li>- Methods of application</li> <li>- Calculations for fertilizer requirements based on soil test data,</li> <li>- Use of bacterial fertilizers,</li> <li>- Role of micronutrients,</li> </ul>	<ul style="list-style-type: none"> <li>- Calculation for fertilizer requirements based on soil test data,</li> <li>- Application of fertilizers and manures,</li> <li>- Inoculation of bacterial fertilizers,</li> </ul>	<ul style="list-style-type: none"> <li>- Skillfulness</li> <li>- Comprehension</li> </ul>
3.6.1	Maintenance and upkeep of laboratory equipment,	<ul style="list-style-type: none"> <li>- Various glassware and equipment and their use</li> </ul>	<ul style="list-style-type: none"> <li>- Operation of basic laboratory equipment</li> </ul>	<ul style="list-style-type: none"> <li>- Carefulness</li> <li>- Cleanliness</li> </ul>
3.6.2	Sampling and processing of test material	<ul style="list-style-type: none"> <li>- Methods of sampling</li> </ul>	<ul style="list-style-type: none"> <li>- Sampling of biological material like blood, milk, and milk products, urine, dung, feed etc,</li> <li>- Processing of samples for analysis.</li> </ul>	<ul style="list-style-type: none"> <li>- Accuracy</li> </ul>
3.6.3	Preparing necessary reagents and their storage	<ul style="list-style-type: none"> <li>- Important laboratory reagents and their preparation</li> <li>- Precautions in storage of different laboratory chemicals</li> <li>- First aid methods safety measure against hazards,</li> </ul>	<ul style="list-style-type: none"> <li>- Preparation of reagents</li> </ul>	<ul style="list-style-type: none"> <li>- Accuracy</li> </ul>

1	2	3	4	5
3.6.4	analysis of test material	- Methods of analysis	- Analysis of test material	- Accuracy Carefulness
3.6.5	Cleaning of glassware	- Different detergents and their use,	- Washing and cleaning	- Cleanliness
3.7.5	Storage of dairy products	- Storage system for different dairy products,  - Maintenance and upkeep of stores,  - Factors affecting quality of stored products  - Use of fumigants	- Sanitation and fumigation of stores,	- Carefulness
3.7.7	Cleaning and sanitation of equipment	- Different detergents and sanitizers  - Methods of cleaning and sanitation  - Water quality	- Analysis of water - Cleaning and sanitization of equipment	- Carefulness - Cleanliness
3.9	<u>Farm Recycling Assistant</u>			
3.9.1	Finding out the extent of availability of various farm wastes	- Different farm wastes		

1	2	3	4	5
3.9.2	Planning for utilization as gohar gas/bio-gas comp st, etc.,	- Principles of recycling - Types of gohar gas plant - compost making  - Layout and preparation of gohar gas and compost pit  - Loans and subsidies	- Layout of gohar gas and compost pit	- Comprehension  - Hard work
3.9.3	Collection and processing offarm waste	- Method of processing waste - Methods of compost making	- Making of slurry for gohar gas plant killing of compost pit	- Dignity of labour - Hard work - Sincerity
3.9.4	Distribution of gas and utilization of recycled material	- Different uses of gas and types of connections  - Compeition of slurry and compost.	- application of slurry and compost	- Carefulness  - Hard work
3.9.5	Educating the farmers for proper utilization of farm waste.	- Importance of recycling of farm waste		- Comprehension
3.10	<u>Secretary Milk Cooperatives</u>			
3.12	<u>Manufacture of Dairy Products</u>			



1	2	3	4	5
3.12.4	Creating the infrastructure	- Building, Equipment utensils, chemicals, glass wares, detergents and sanitizers.	- Model schemes for handling 100 and 200 liters of milk	- Hard work - Dignity of labour,
3.13.4	Creating infrastructure,	- Buildings, machineries, chemicals, laboratory, glass-ware, fumigants detergents, etc.	- Model scheme for manufacturing one ten compounded product per day.	- Hard work - Dignity of - Comprehensive

4

5

ent utensils,  
wares,  
e nitizers.

- Model schemes for handling  
100 and 200 liters of milk

- Hard work  
- Dignity of  
labour.

neries,  
actory,  
migrants

- Model scheme for manufact-  
turing one ten compounded  
product per day.

- Hard work  
- Dignity of  
- Comprehension

### Theory

Principles of Animal Housing, animal sheds, designs of animal house. Materials used in construction. Animal responses to environmental changes, Protection against heat and cold,

Definition of health and diseases. Signs of health. First aid and treatment for common ailments diarrhoea, dysentery, indigestion, tympanitis, injuries and wounds, Symptoms and preventive measures for animals. Diagnosis and prophylaxis of common diseases like Anthrax, Rinderpest, Black Quarter. Haemorrhagic septicemia, tuberculosis and Foot and Mouth disease. Eradication of parasite infestation and worms. Symptoms of diseases of reproductive tract. Mastitis and its control. Yearwise vaccination schedule against common diseases.

### Practicals

- Feeding colostrum to new born calf
- Determination of pulse, temperature and respiration
- Testing milk for mastitis

### Theory

Soils of India. Classification of soil on the basis of colour and texture. Physical and chemical properties of soil. Soil and water sampling, their processing and despatch. Factors affecting soil fertility and productivity. Types of manures and fertilizers and the principles of their application. Agricultural meteorology.

Importance of fodder production and methods of conservation. Methods of silage making - suitable crops, changes during cutting, ensiling, enrichment of silage and preparation of silage from straws, Hay making. Nutrient losses during conservation. Farm by-products and their storage,

Importance and utilization of farmine feeds unconventional fodder crops and their leaves, Pasture and their management.

-: 10 :-  
Practicals

- Soil and water sampling
- Compost making
- Visit to bio-gas plants and study of:
  - i) Layout and operation
  - ii) distribution and utilization
- Calculation of fertilizer requirements for different crops based on soil test data

Theory

Importance of nutrition in animal production. Common feeds used for various feed stuffs. Classification of feed stuffs and their categorisation into basal feeds, protein, energy, mineral, vitamin supplements, feed additives, agro-industrial by products and un-conventional feeds and feeders.

Selection of feeds, formulation, grinding, mixing, pelleting, packaging and storage, Preparation of mineral mixture-ingredients, their availability, grinding, mixing and storage, Advantages and disadvantages of compounding and pelleting. Principles of storage and maintenance of stores,

Indian Standard Institute (ISI) specification for various feed ingredients and compounded feeds, Feeding schedules for various categories of animals viz. new born, growing calves, heifers, milch animals breeding bulls bullocks and dry animals, Metabolic disorders, their causes, identification, prevention and remedy.

Practicals

- Sampling and labelling of feed, feeders, urine
- Preparation of various laboratory reagents and standard solutions
- Determination of Moisture/Dry matter
- Preparation Ether Extract
- Determination of Nitrogen Free Extract

- Determination of Total Ash and Soluble Ash

- Identification and application of insecticides and fumigants
- Preparation of mineral mixtures
- Calculation of feed and fodder requirements of dairy farm having 5 milch cattle with dependants.
- Organisation of a feed analysis laboratory its equipment, glasswares and chemicals.

Theory

Endocrinology of reproduction. Primary and secondary hormones of reproduction. Role of hypothalamus, pituitary organs in reproductive cycle. Role of F.G.H., L.H., prolactin, estrogen progesterone, testosterone, oxytocin in reproduction.

History of artificial insemination, advantages and limitation of A.I. Methods of semen collection. Sex behaviour and libido in males. Physical, microscopic and chemical tests for evaluation of semen. Qualities of a good semen extender, semen extenders, extension of semen, dilution rate determination.

- Practicals
- Washing, cleaning and sterilization of A.I. equipment
  - Chemical examination of semen, pH methylene blue reduction test and catlass test.
  - Demonstration of deep freezing of semen, labelling of straws, their filling, and preservation in liquid nitrogen
- Physical and chemical properties of milk, Types of micro-organisms present in milk, milk in relation to public health.

Functioning of chilling centres. Milk reception, testing and grading at chilling centre. Different methods of chilling and storage. Modes of transport of chilled milk. Equipment used in reception of milk-vessels, cans, tankers, Receiving devices.

Principles of clarification, separation and pasteurization of milk. Methods of pasteurization. LTLT and HTST. Methods of packing, different packing materials, Dispensing of milk through bottles, cartons and pouches, standardization, homogenization and sterilization of milk.

Manufacture, composition and defects of different milk products- cream, butter, ghee, Khoa, chhana, paneer, milk based sweets, curd, ice cream etc.

Storage of processed milk and milk products . Maintenance and care of stores. Spoilage during storage . Transportation of milk products.

Sampling procedures for milk and milk products, labelling of samples, Testing of samples-Platform and routine tests.

Milk standards and legislation regarding quality and sanitation. Types of detergents, sanitizers and their use. Washing and sanitization of dairy equipment.

#### Practicals

- Chilling of milk
- Straining and clarification
- Cream separation of milk
- Standardization of milk
- Pasteurization of milk
- Preparation of Flavoured milk
- Preparation of sterilized milk
- Preparation of cream
- Preparation of butter
- Preparation of ghee
- Preparation of Khoa
- Preparation of Chhana
- Preparation of paneer
- Preparation of Kalakand/Burfi
- Preparation of curd
- Preparation of ice cream
- Preservation of milk samples and their analysis
- Cleaning and sanitization of dairy equipment
- Gerber fat test
- Determination of specific gravity of milk by lactometer reading.

- Determination of titrable acidity in milk
- sediment test
- Clot-on-boil (COB) test
- Resazurin test
- Analysis of dairy products to meet standard

7. Suggested list of Laboratory Chemicals

Fertilizers, detergents, pesticides etc.

1.	Sulphuric acid (C. Grade)	5 litres
2.	Sulphuric acid (L.R)	5 litres
3.	Amyl alcohol	2x 500 ml
4.	Sodium hydroxide (pellets)	500 gms
5.	Litmus paper	blue and red
6.	Filter paper (Whatman No. 1 & 40)	1 packet each
7.	Petroleum ether (40 -60°C)	5 litres
8.	Copper sulphate	500 gms.
9.	Sodium sulphate	500 gms.
10.	Potassium dichromate	500 gms.
11.	Sodium bi-carbonate	500 gms
12.	Oxalic acid	500 gms.
13.	Eosin water soluble	25 gms.
14.	Nigro sine water soluble	100 gms.
15.	Methyl blue	25 gms.
16.	Resazurin	25 gms.
17.	Phenolphthalein	25 gms.
18.	Petroleum jelly/liquid paraffin	500 ml
19.	Spirit	5 litre
20.	Mustaid solution	500 ml
21.	Sodium citrate	500 ml
22.	Glucose	500 gms
23.	sulphanilamide	100 gms
24.	Penicillin G-Sodium	5 x 1 gm

25.	Streptomycin sulphate	5 x 1 gm
26.	Amatto colour	
27.	Butter salt	500 gms
28.	Sodium alginate	500 gms
29.	Colour for ice-cream	
	Straw berry.	
	Rose	
	Coffee	
	Flavour for ice-cream	
	Vanilla	
	Pine apple	
	Orange	
	Banana	
30.	W.B.C. Diluting fluid	
31.	R.B.C. Diluting fluid	
32.	Ammonium sulphate	
33.	Urea	
34.	Super phosphate	
35.	Rock Phosphate	
36.	Potassium sulphate	
37.	Muriate of potash	
38.	Zink sulphate	
39.	Citric acid	
	<u>Pesticides</u>	
40.	Malathi	
41.	Formaldehyde	
	<u>Detergents</u>	
42.	Tea pol	
43.	Liquid soaps	
44.	Vim	
45.	Bleaching powder	



8. Suggested list of equipment and tools

S.No.	Name of articles	Quantity
1.	Syrings 10 ml	3
2.	First Aid Kit	2
3.	Tongs	2
4.	Liquid Nitrogen contained (complete 3 lit. cap).	1
5.	Hot air oven	1
6.	Autoclave	1
7.	Syrings sterilizer	1
8.	Hot plates	1
9.	Soxhlet apparatus	1
10.	Water distillation apparatus	1
11.	Muffle furnace	1
12.	Enamel trays	2
13.	Moisture boxes	10
14.	Chemical balance	10
15.	Weight box	1
16.	Incubator	1
17.	Milk measures 250 ml	1
	500 ml	1
	1000 ml	1
18.	Triped stands	2
19.	Pestle and Mortar	2
20.	Grinder (Hand operated)	1
21.	Semen Shippers	2
22.	Resazurin colour comparator	1
23.	Strainers	6
24.	Volumetric flask 100 ml, 250 ml, 1000 ml, 2000 ml.	5
25.	Reagents bottles 250 ml	10
		10

27.	Dealcator	1
28.	Wash bottles 500 ml cap.	10
29.	Glass tubing	1
30.	Spirit lamps	10
31.	Slides and cover slips	100
32.	Indicator bottles	10
33.	Sample bottles	50
10.	<u>Suggested list of miscellaneous items</u>	
1.	Kerosene	1 tin
2.	Musline cloth	1 meter
3.	Burette stand	10
4.	Test tube stand	10
5.	Rubber tubing	10 mt.
6.	Taps	1 gross

